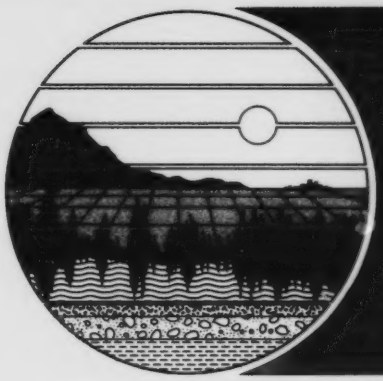

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LAND USE CHANGE EVALUATION OF CANADIAN LRTAP CALIBRATED WATERSHEDS

By

J.C. Moyes

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ABSTRACT

Through the Long Range Transport of Airborne Pollutants (LRTAP) Program, federal and provincial agencies have cooperated in establishing five major calibrated watershed areas in Eastern Canada. These sites, located at the Experimental Lakes Area, Turkey Lakes, and Dorset in Ontario, Lac Laflamme in Quebec, and Kejimkujik National Park in Nova Scotia were selected in order to conduct baseline ecosystem dose-response research.

An important factor in ecosystem response to acid deposition is ecosystem stability and land use change. This report documents historical and chronological land use change in the five calibrated watersheds through air photo interpretation of the watersheds between 1920-1950 and 1950-1980. The document also provides an ecological description and an interpretation of the regional representativeness of each of the watershed areas.

The study indicates that several of the calibrated watersheds have undergone or continue to undergo significant natural environmental changes including forest maturation and regeneration after fire, logging or abandonment of farmland. Man induced alterations include logging, and the building of roads and cottages. However, some of the watersheds have had little change in land cover or land activity in the last 40-60 years. The areas are generally representative of their region, provide a varied selection of Eastern Canada ecosystems and exist under a significant range of acid deposition levels.

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1.0 INTRODUCTION

It has generally been presumed that the calibrated watersheds are representative of several Eastern Canada landscapes and are relatively stable, pristine ecosystems. However, there is no document readily available that justifies these presumptions. In addition, there has been extensive literature published on the LRTAP research within the individual calibrated watersheds but the there is no baseline report tying the watersheds together or identifying past and current land use and land activity.

Because ecological stability, land use and land use change affect surface water pH, it has been recognized that they are significant factors in determining acid precipitation effects and subsequently must be considered in the development of target loadings and emmission control strategies.

A number of studies (Drablos et al. 1980; Narver 1971; Nilsson et al. 1982; Rosenqvist 1978; Seip and Tollan 1978; Timberlid 1980) support the concern that both local and macro-level land activity and land cover changes may significantly contribute to modification of dynamic ecosystem elements such as water chemistry and survival of biota. Kessel-Taylor (1986) suggests that the collective contribution of the effects of land use change (forestry practices, fire), occurrence of peatlands, fisheries management, and acid precipitation are all contributory factors to the decline of Atlantic salmon in Nova Scotia. To date, the only focus in the literature for this decline has been the influence of acid precipitation, which Kessel-Taylor notes must not be considered in isolation from other contributing influences.

This study was initiated in 1985 to fill the baseline data gap by examining the land cover and land activity changes in the five calibrated watershed areas, providing for each a general ecological description and determining their regional representativeness. For the purposes of this report, the term "land use" is used when collectively referring to "land cover" (forest, cropland, pasture) and "land activity" (logging, farming, recreation). The project has the following objectives:

(1) to delineate in map form and with tabular statistics the stability or changes in land cover and land activity in each calibrated watershed for the periods 1920-1950 and 1950-1980;

(2) to document the original rationale for selecting each calibrated watershed and to outline a general ecological description of each watershed; and

(3) to evaluate the regional ecological setting and general representativeness of each calibrated watershed.

2.0 THE WATERSHEDS

The five calibrated watershed study areas, as located in Figure 1, are as follows:

(1) The Experimental Lakes Area is located approximately 52 km southeast of Kenora, Ontario and is managed by the Freshwater Institute, Fisheries and Oceans Canada. It covers 17 203 ha and incorporates over 200 lakes, for the main purpose of whole lake ecosystem response research. Only a small number of lakes are under study.

(2) The Turkey Lakes Watershed is comprised of a set of five interconnected lake basins covering 1 050 ha about 50 km north of Sault Ste. Marie, Ontario. This is Canada's most intensively monitored calibrated watershed and is managed by the Canadian Forestry Service, Fisheries and Oceans Canada, the Inland Waters Directorate of Environment Canada, and the Ontario Ministry of Natural Resources.

(3) Dorset Catchments consist of a series of eight individual basins in the Muskoka region within a 70 km range of Dorset, Ontario. Studies in this area are managed by the Ontario Ministry of the Environment. The eight basins collectively cover an area of 6 082 ha.

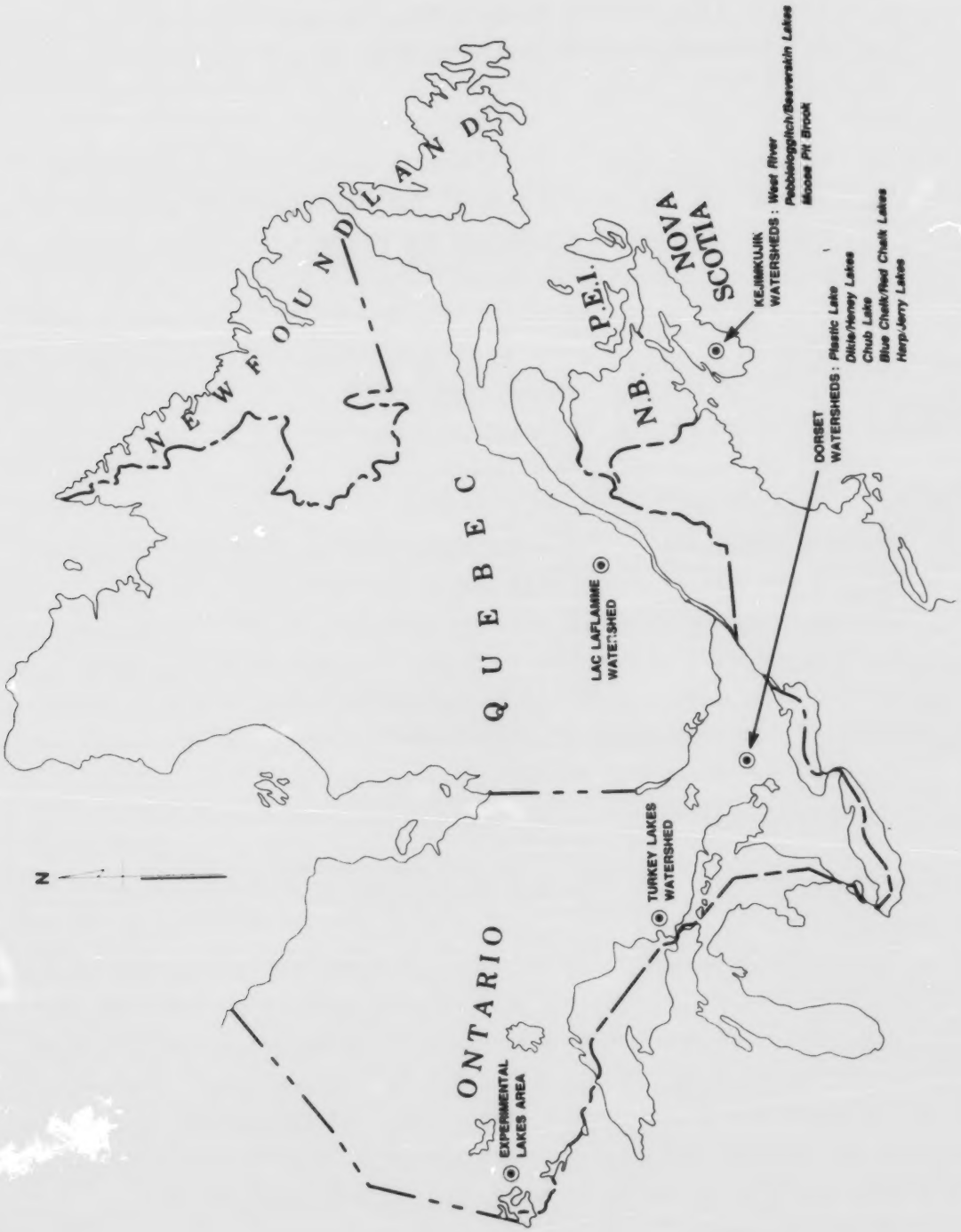

Figure 1: Location of Canadian LRTAP Calibrated Watersheds

(4) The Lac Laflamme Watershed is an individual headwater basin covering 494 ha, approximately 40 km north of Quebec City, Quebec. The area is intensively studied and managed by the Canadian Forestry Service, Agriculture Canada.

(5) Kejimkujik National Park includes a series of separate studies linking several major basins of the southwest portion of the Park. The basins cover 13 521 ha and lie 200 km southwest of Halifax, Nova Scotia. The studies are being managed by the Inland Waters Directorate and Canadian Wildlife Service of Environment Canada. Moose Pit Brook, a separate 2 851 ha study basin, is located 10 km east of Kejimkujik National Park and is the focus of joint monitoring by the Inland Waters Directorate of Environment Canada and Fisheries and Oceans Canada.

As noted above, each of the watersheds has been developed and managed through the lead of one or more particular federal or provincial government agency. Table 1 provides a general overview of the agencies and general areas of research conducted in the calibrated watersheds for the period 1980-86. It should be acknowledged that numerous university research participants are also involved in some of the watersheds but these are not presented in Table 1.

3.0 METHODOLOGY

In order to determine land use and its changes over the last 60 years, up to three sets of air photos from different years were interpreted for each calibrated watershed. A base map was created for the first time period and land use changes delineated for the subsequent coverages. A literature review and communications with various researchers provided the information for the discussion presented here on the ecological overview, site selection criteria, and evaluation of regional representativeness.

The base maps were generated from 1:50 000 NTS map sheets; however, the final map of each watershed was presented at the scale best suited to

TABLE 1

FOCUS OF LRTAP RESEARCH, BY AGENCY, IN CANADIAN CALIBRATED WATERSHEDS

RESEARCH AND MONITORING COMPONENTS	EXPERIMENTAL LAKE AREA	TURKEY LAKES WATERSHED	DORSET BASINS	LAC LAFLAMME WATERSHED	KEJIMKUJIK PARK	MOOSE PIT BROOK
Atmospheric Chemistry Monitoring	AES	AES	AES	AES	AES	-
General Precipitation Monitoring	FOC	CFS, IWD	FOC	AES	AES	IWD
Forest Vegetation and Productivity Impacts Monitoring	CFS	CFS	MOE, MNR	CFS	CFS	-
Forest Throughfall Chemistry Monitoring	-	CFS	MOE	CFS	-	-
Soil Impacts Monitoring/Evaluation	-	CFS	MOE, MNR	CFS	CFS	LDS
Ecosystem Classification/Mapping	LDS*	LDS	MOE	-	PC *	LDS
Stream, Lake Water Monitoring	FOC	CFS, FOC, IWD	MOE	IWD	IWD	IWD
Groundwater Monitoring	-	IWD	MOE	CFS, IWD	-	-
Aquatic Biology Monitoring	FOC	FOC, CWS	MOE	CWS	CWS	FOC
Wetland Monitoring/Evaluation	FOC	CWS	-	-	LDS, CWS	LDS
Wildlife Effects Evaluation	-	CWS	-	CWS	CWS	-

* Conducted prior to LRTAP Program.
CFS - Canadian Forestry Service, (Sault Ste Marie, Ste. Foy, Fredericton)
FOC - Fisheries and Oceans Canada (Winnipeg, Burlington, Dartmouth)
IWD - Inland Waters Directorate, Environment Canada (Saskatoon, Burlington, Ottawa, Ste. Foy, Moncton)
LDS - Lands Directorate, Environment Canada (Ottawa, Burlington, Dartmouth)
CWS - Canadian Wildlife Service, Environment Canada (Ottawa, Ste. Foy, Halifax)
AES - Atmospheric Environment Service, Environment Canada (Downsview)
MOE - Ontario Ministry of Environment (Toronto, Dorset)
PC - Parks Canada (Halifax)
MNR - Ontario Ministry of Natural Resources (Sault Ste. Marie, Toronto, Dorset)

detect and record land cover and activities. The set of maps for the study areas consist of several base maps, plus overlays which are kept on file by the Lands Directorate, Environment Canada. These maps provide the location of all land activity and cover in the base year, as well as delineating land use change occurences in each of the subsequent coverages. It should be noted that this report includes small areas outside of the physical boundaries of the watersheds generally because of the difficulty of identifying the limits of the watershed or due to mapping and interpretation considerations. All numerical land use coverage totals used in the analysis include these surrounding areas.

For the purposes of recording land use changes, a base year was selected and two later dates were used to identify land use changes over the two time periods:

1. Land use 1920 ("base year");

2. Land use change 1920-1950; and

3. Land use change 1950-1980.

The actual time period for coverages of each watershed differs slightly depending upon the availability and suitability of air photography.

A complete land use classification base map was created from air photographs for the 1920 base year identifying and delineating all land cover and activities. The map was then digitized to calculate areas in hectares. In the 1950 and 1980 coverages, only land uses that had changed in the interim were mapped and digitized. The land use change maps are presented as overlays to the base maps.

The results from the land use base maps, the land use changes and area calculations are presented in text and tabular form in this report. To facilitate the tabular presentation of this information, the original land cover and land activity data are grouped into classes based upon a modified land cover/activity classification (Gierman 1985) developed for

the Canada Land Use Monitoring Program of Environment Canada. Table 2 defines the classes and shows the corresponding map symbols that were used. A list of the photographs used is given in Appendix A for each watershed.

4.0 CALIBRATED WATERSHEDS: ANALYTICAL RESULTS

This section discusses the location, ecological description, criteria for establishment, regional setting and the results of the land use analysis of each of the calibrated watersheds. A generalized summary of the ecological characteristics of each watershed is presented in Table 3. A summary of land use changes in the watersheds is presented in Table 15 in section 5.0 of this report.

4.1 Experimental Lakes Study Area, Ontario

4.1.1 Regional Setting

The Experimental Lakes Area (ELA) is located approximately 52 km southeast of Kenora, Ontario. The physiography of the region reflects the underlying bedrock of Precambrian granite, although volcanic basalt, andesite and greenstone are also common. The topography is generally hilly with many lakes, and wetlands in depressions.

The surficial geology has been strongly influenced by glacial deposits of which much is derived from local bedrock. Ground moraines, consisting of sandy deposits mixed with stones and gravel, are plentiful. Deposits of sand and gravel composed of quartz, plagioclase, and K-feldspar are associated with lakes and streams while deposits of fine and medium sands in plains and valleys are found northeast of the Experimental Lakes Area. Glacio-lacustrine clays occur in valleys and on rock knobs while organic deposits are found in local depressions. Exposed bedrock and rocky hills are common throughout a wide region of the Kenora District (Brunskill and Schindler 1971).

TABLE 2

MODIFIED LAND ACTIVITY/LAND COVER CLASSIFICATION

LAND ACTIVITY CLASS	LAND COVER CLASS
A1 - Annual tillage crops, forage and grazing A2 - Fruit, berry, and nut production A3 - Other productive agriculture A4 - Agricultural site activity B1 - Former agricultural land B2 - Former forestry land B3 - Other former activities D0 - Dwelling E0 - Extraction F1 - Productive forestry land F2 - Forestry site activity G1 - Productive wildlife and/or fisheries activity G2 - Wildlife and/or fisheries site activity H0 - Transportation and communication J0 - Institutional services L0 - Land in transition M1 - Commercial, manufacturing and storage M2 - Waste treatment/disposal N0 - No perceived activity N1 - Unvegetated forest fire burn N2 - Partially regenerated burn O7 - Urban undifferentiated O8 - Unclassified P0 - Ecological research, conservation, flood control, drainage R1 - Land dependent recreation R2 - Indoor/outdoor recreational or cultural site activity	O7 - Urban O8 - Unclassified V1 - Row Crop V2 - Close-grown crop V3 - Improved grassland V4 - Unimproved grassland, reeds, sedges, mosses, and other woody plants W1 - Trees W2 - Shrubs, bushes, vines X0 - Barren surface Y0 - Constructed cover Z0 - Water

Source: Gierman (1985).

TABLE 3

GENERAL ECOLOGICAL CHARACTERISTICS OF EACH CALIBRATED WATERSHED

ECOLOGICAL CHARACTERISTICS	DORSET STUDY AREAS	TURKEY LAKES WATERSHED	EXPERIMENTAL LAKES AREA	LAC LAFLAMME	KEJIMKUJIK STUDY AREAS
Bedrock Type	granite, syenite, gneiss, migmatite, schist, amphibolite	greenstone, granite	granite, basalt, greenstone	gneiss mangerite	granite, slate schist, quartzite, greywacke
Soil Types	Podzols, Brunisols	Orthic Humo-Ferric Podzols Orthic Ferro-Humic Podzols	Eutric Brunisols, Podzols	Orthic Humo-ferric Podzols	Humic Podzols
Soil Texture	sand, silt loam	sandy loam, silty loam, loamy silt	sand, gravelly clay	sandy loam, stony sand	sandy loam
Soil Depth	shallow, 30-40 cm	deep, > 1 m	shallow, < 1 m	deep (4-20 m)	shallow to deep
Surficial Materials	moraine plains, peat, lacustrine plains	stony moraine	ground moraine, lacustrine clays, rock outcrops	moraine	ground moraine, outwash, kames, drumlins
Topography	rolling bedrock and level plains and outwash deposits with frequent bogs	strongly broken upland with steep slopes	rolling plains	steep hills	undulating to rolling plain
Elevation (m)	300-450	230-630	360-380	655-945	106-168
Forest Species	Sugar Maple, Silver Birch, Yellow Birch, White Pine, Red Pine, Basswood, Hemlock	Sugar Maple, Yellow Birch, White Spruce, White Pine, Red Maple, Black Ash	Aspen, Jack Pine, Balsam Fir, White Birch, White Spruce, White Pine, Poplar, Black Spruce	Balsam Fir, White Spruce, Birch	Balsam Fir, Red Spruce, White Spruce, Hemlock, Pine, Maple, Oak
Mean Annual Temperature (°C)	3.0	3.3	0.5-2.2	0.2	6.5
Mean Annual Precipitation (mm)	890	1 123	660	1 430	1 400
Wet Sulphate 1980 Annual Loading (kg/ha/year)	33	31	6	45	17
No. of Lakes in Study Area	8	5	> 200	1	16
Total Area (ha)	6 083.2 (sum of 5 areas)	1 265	17 203.3	494.3	16 382.6 (sum of 3 areas)

The region is dominated (75%) by thin, stony, morainal soils. The soils are Podzolic and generally well-drained. Well-drained soils over clay are common, with medium and fine textured sands surrounding the clay deposits. Stony sands and gravels are located on moraines, with one of the largest deposits being directly east of the study area on the north shore of Eagle Lake (Rubec 1976).

The region supports a variety of trees, shrubs and herbs. Wet areas tend to support Black Spruce, Tamarack, Eastern White Cedar, Black Ash and White Elm. Drier sites contain stands of Trembling Aspen, Jack Pine, Balsam Fir, White Birch, White Spruce, White Pine and Balsam Poplar. Manitoba Maple, Bur Oak and Basswood occur occasionally.

The mean annual temperature is between 0.5 and 2.2°C with an annual precipitation of approximately 660 mm. In 1980, the ELA had an mean annual wet sulphate loading of 6 kg/ha/year. Most of the area is mapped as having a low potential to reduce the acidity of atmospheric depositions (Memorandum of Intent 1983).

Much of the soil in the region is not suited for agriculture. Shallow soil depth and stoniness make agriculture impractical. Examination of Canada Land Inventory maps, indicates 75% of the land in this region has no capability for permanent agriculture. Forestry dominates and provides the main income in the region. Tourism is expanding as the area becomes better known as a source of fish and game (Hoffman 1967).

4.1.2 Establishment of Study Area

The Experimental Lakes Area is a limnological research facility established originally by the Fisheries Research Board of Canada in the 1968. The Experimental Lakes Area watersheds were selected according to five specific criteria:

1) Accessibility: The need for ease of access into the area (logging roads) and proximity to Winnipeg had to be balanced with the desire to select undisturbed environments for research. The ELA is permeated with small lakes, streams and bogs and as a result remains largely isolated from the relatively more populated areas to the north. Logging operations which began in 1953, were centred to the north, south and west of MacDonald Lake, away from the main ELA research station. Roads into the area were originally established for forestry purposes and now provide much of the access to the lakes. Nearby logging operations and hunting and sport fishing camps do not appear to influence the immediate watersheds under intensive research. Access to the area for recreational use has been restricted since 1967 and a protective forestry lease has preserved the area from logging for the foreseeable future.

2) Lake Volume: The volume and containment of water suitable for experimental manipulation in eutrophication and uptake experiments were the second major criteria used to select research lakes within the ELA. Most inventoried lakes and those now under study are in headwater basins.

3) Morphometry: Proper lake morphometry suitable for development of thermal stratification studies was required. The large number of lakes within the region (over 200 have been inventoried) provided a large selection from which to choose the proper lakes for experimentation (Brunskill and Schindler 1971). Most lakes under study are less than 60 ha in size and less than 30 m deep.

4) Undisturbed Environment: Basins had to be essentially undisturbed by fire and logging in order to carry out meaningful research.

5) Typical Environment: The area was chosen to be generally representative of the boreal zone on the Canadian Shield (G.M. Wickware, personal communication).

In addition to aquatic research, preliminary studies at the ELA have involved topographical, climatic, geological and water-quality analysis as well as general ecological inventories of individual drainage basins. A wetland survey, a soil development analysis, and an atmospheric monitoring study have also been completed or are ongoing. An ecological land survey of this area was conducted at 1:20 000 scale (Wickware and Rubec 1976).

4.1.3 Study Area Description and Land Use History

The Experimental Lakes Area is a large research site comprised of 46 intensively studied lakes and over 200 inventoried lakes located around lat. 49°39'N., long. 93°44'W.. The area has an average elevation of 360-380 m above sea level a.s.l. with relief that rarely exceeds 80 m. Figures 2 and 3 are representative views of basins in the ELA.

The study area is underlain by Precambrian granite which contain dykes of aplite and pegmatite. Hill tops and slopes in the ELA usually have exposed rock or thin soil. Low-lying areas often have thin deposits of ground moraine and outwash deposits. The soils generally consist of degraded Eutric Brunisols of varying thickness (rarely greater than 30 cm) or Podzols overlying coarse sands. They are generally extremely thin and mixed with gravels, stones and boulders. Organic deposits are located in local depressions and on poorly drained wetland sites (Rubec 1976; Bayley and Vitt 1984).

Typical tree species found in the study area include Jack Pine on exposed rock slopes and hilltops and Black Spruce with Jack Pine on well-drained morainal slopes. Trembling Aspen and White Birch are scattered throughout most of the other stands and occasionally occur alone on exposed sites. Black Spruce dominates the wetland areas.

Figure 2: Aerial view in 1976 of several major lakes in Experimental Lakes Area with surrounding forested rock knob topography

Figure 3: Lake 226 in the Experimental Lakes Area has been used for whole lake studies, July 1976

Red Pine is usually confined to pure stands located along sandy ridgetops or lakeshores.

The distribution of some tree species (i.e. White Spruce) has been greatly reduced by fire. It would appear that prior to 1970, small localized fires went through the area every 25-50 years (Brunskill and Schindler 1971). The last major fire (and one of the largest ever in Ontario) which affected part of the study area was in July 1974 covering 38 023 ha. The fire consumed the areas roughly bordered by the ELA camp in the west, Eagle Lake in the east, Delano Lake in the north, and Stoat Lake in the south.

The main ELA camp area was also burned over in 1980. As a result of negotiations with the Province of Ontario most of the watersheds burned in 1974 or 1980 were released from the ELA leased area. Several new unburned watersheds were added to the north and west of the ELA camp as well as various wetlands and stream sections for experimental use. None of the major basins currently under study appear to have even been logged (D.W. Schindler, personal communication).

Since 1967, logging activities have been halted around lakes used for intensive research. Ontario government regeneration and reseeding projects are ongoing throughout the area. Recent logging in the surrounding areas has brought more boreal species into prominence. Research indicates that, in some areas, clear-felled and scarified Jack Pine - Black Spruce forest regenerates within 10 years (Ellis and Mattice 1974).

Land Use History

Evaluation of historical land uses in the Experimental Lakes Area is hampered by the lack of suitable air photography. As a result, only one coverage has been interpreted and mapped. It should be noted that some classes may be intermingled due to poor photo scale and quality. The three classes to which this most applies are exposed bedrock, burns and partially regenerated burns.

The system employed to classify land uses (Gierman 1985) allows two specific covers to be interpreted under one class for complex units. The cover that accounts for the largest percent of the area takes precedent. Bedrock is exposed throughout much of the ELA study area - both as a natural cover and as a result of logging and burns. It is often intermingled with undergrowth, grass, mosses and small shrubs or isolated stands of trees. At the mapping scale of 1:25 000, it is impossible to separate the areas of bedrock from areas of regeneration or natural growth.

It may be assumed (for the ELA area only) that where the cover class of V4 (grasses, sedges) appears in conjunction with the activity classes N1 (burns), N2 (regeneration), B2 (abandoned agriculture) or F1 (active forest land), a portion approaching 50% of the V4 (grasses) class will be made up of exposed bedrock. Bearing this in mind and allowing for a 1% error margin within the V4 class, bedrock exposures occur over approximately 11% of the study area (burn areas are tabulated as natural phenomena). Small wetlands, with no visible water, fall under a variety of classes.

The only suitable photography available for the ELA is for 1969 and does not reflect recent large scale forest fires. For the purposes of this report, the rough boundaries of the mapped area are Veronica Lake in the west, Teggau Lake in the east, Porcus Lake in the north, and Point Lake in the south. The entire map area encompasses 17 203.3 ha. Table 4 compares the 1969 land use with a 1975 general land cover evaluation using LANDSAT satellite digital image analysis (Rubec and Wickware 1978). Due to rounding-off, some areas do not total to 100% in Table 4 or subsequent tables.

1969 - Natural covers (including burns) encompassed 90.2% of the area while man-influenced covers accounted for 9.7% in 1969. Heavily forested unburnt classes occupied 42.7%. Immature forest, shrub and grass classes (excluding burns) totalled 5.4%. Recent burns (including logged burns) accounted for 10.9% while regenerated burns occurred on 9.7% of the total

TABLE 4

EXPERIMENTAL LAKES AREA, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1969 Coverage		1975 Coverage (Rubec and Wickware 1978)	
	ha	(%)	ha	(%)
Natural Classes				
Shrubs, Trees No Activity (W2, W1/N0)	7 321.2	42.6	5 622.8	46.7
Water (Z0)	3 735.1	21.7	3 364.2	27.9
Shrubs, Grasses/Burned Barren (W2, V4/N1)	1 767.3	10.3*	334.4	2.8
Shrubs, Trees/Fire Regeneration (W2, W1/N2)	1 717.5	10.0**	1 228.0	10.2
Grasses, Shrubs/No Activity (V4, W2/N0)	547.4	3.2		
Shrubs/No Activity (W2/N0)	280.3	1.6		
Grasses/No Activity (V4/N0)	74.5	0.4		
Shrubs, Grasses/No Activity (W2,V4/N0)	34.0	0.2		
Shrubs, Grasses/Fire Regeneration (W2, V4/N2)	12.5	0.1**		
Shrubs, Trees/Burned Barren (W2, W1/N1)	12.5	0.1*		
Trees, Shrubs/No Activity (W1, W2/N0)	2.9	-	918.2	7.6***
Sedges, Water/No Activity (V4, Z0/N0)	2.4	-		
Man Influenced Classes				
Grasses, Shrubs/Abandoned Forestry (V4, W2/B2)	530.1	3.1		
Grasses/Abandoned Forestry (V4/B2)	388.1	2.3		
Shrubs, Grasses/Active Forestry (W2, V4/F1)	215.9	1.3	582.8	4.8
Grasses/Active Forestry (V4/F1)	204.4	1.2		
Shrubs, Trees/Abandoned Forestry (W2, W1/B2)	130.6	0.8		
Shrubs, Grasses/Abandoned Forestry (W2, V4/B2)	90.1	0.5		
Shrubs, Grasses/Abandoned Forestry, Burned Barren (W2, V4/B2, N1)	63.0	0.4*		
Grasses, Shrubs/Abandoned Forestry, Burned Barren (V4, W2/B2, N1)	33.2	0.2*		
Shrubs/Abandoned Forestry (W2/B2)	32.9	0.2		
Trees, Shrubs/Abandoned Forestry (W1, W2/B2)	7.3	-		
Barren Built-Up/Abandoned Forestry (X0, Y0/B2)	0.1	-		
Total Area	17 203.3 ha	100%	12 050.4 ha	100%

* Total 1969 "Burned" Area = 1 876.0 ha (11.0%)
** Total 1969 "Regeneration" Area = 1 730.0 ha (10.1%)
*** This class does not readily compare with 1969 data as specific forest species were chosen for analysis.

area. Active forestry accounted for 2.5% while recently abandoned forestry encompassed 6.6% and abandoned but regenerated forestry occupied 0.8%.

The land use map from 1969 shows a landscape scarred by fire and logging. Recent and regenerated burn areas are spread relatively evenly over the area. Most burn scars run in a northeasterly direction. They tend to cover fairly small areas and, although the distribution of the burns is extensive, individual burn areas rarely exceed 20 ha. The largest burn area evident in 1969 is approximately 431 ha and is located in the southeast corner of the study area.

Much of the abandoned logging area in 1969 was concentrated in three locations. The northwest section of the study area showed signs of recent forestry with the main cover being a mixture of grass, shrubs, bedrock and exposed soil. Many small trails ran through this section and there are signs of trail abandonment in some locations. A well-maintained road ran south to another smaller area of older abandoned forestry in the west central portion of the study area. The road continued south to an area of active forestry surrounded by recently abandoned forestry and smaller areas of regenerated cover.

Most of the rest of the study area did not show signs of recent forestry. The only other man-influenced development was a section of small clearings in the centre of the study area, the site of the present-day research centre. A small road runs east from the camp to the south shore of Teggau Lake.

1975 - LANDSAT image analysis of the Experimental Lakes Area was undertaken by Rubec and Wickware (1978) to map the distribution of six major cover types: open water, recently disturbed cutovers, recent burn areas with rock and bare

soil, regenerating forest, mature forest, and mixed immature forest, as listed in Table 4.

While the methods used for interpretation in this report for 1969 and the Rubec and Wickware (1978) study for 1975 are quite different (aerial photography analysis versus four-dimensional histogram LANDSAT digital image analysis), the two study areas are roughly coincident and reasonably comparable. The specific study areas are quite different in size (17 203 ha versus 12 050 ha) but are coincident on the ELA main camp. Table 4 suggests that burned area decreased from 1969 to 1975 from about 11% to 3% of the ELA; recent cutover forestry sites remained in the 3-5% range; total area of regeneration after fire stayed at about 10% and mixed forest at about 43-47%. "Mature" forest is difficult to define in the 1969 data, while the 1975 figure of 7.6% may be misleading as it is concentrated on clusters of specific forest species. The 1975 study excludes much of the area of the 1974 major fire to the east.

4.1.4 Regional Representativity

The portion of the Experimental Lakes Area studied in this report is quite representative of the Canadian Shield in the immediate area. The shallow soils, sandy moraine and wave-washed outcrops are all common regional features. The topography, the large selection of varying lakes and wetlands, and the man- and fire-influenced vegetation are also found throughout the region.

The ELA, however, lacks deep lacustrine clays (typical of the Lac Seul/Fort Francis area) and deposits of fine and medium sands found just to the northeast (G.M. Wickware, personal communication). The geology of the research area also lacks any quantity of specific, older, more complex bedrock outcrops of schist, greywacke and gneiss, volcanic rocks including basalt and tuff, and intrusive gabbros or hornblende diorites to the east, west, and south of the ELA (Brunskill and Schindler 1971).

The Experimental Lakes Area is one of the areas in Canada most frequently swept by forest fires. This phenomena, combined with logging activities and the shallow soils, may result in substantially greater nutrient runoff than that found across a larger region.

Based upon the regional description and land use data it appears that the ELA study area is representative of the Kenora District of the Canadian Shield but is less representative at the broader regional scale.

4.2 Turkey Lakes Watershed Study Area, Ontario

4.2.1 Regional Setting

The Turkey Lakes Watershed (TLW) study area consists of five lakes in the Algoma District, Ontario. The region is located on the Canadian Shield and is underlain by Precambrian greenstone and granitic bedrock forming a strongly broken upland with steep east/west ridges and elevations ranging between 340 to 630 m a.s.l. Small lakes and streams are numerous in the region.

The entire area has been strongly influenced by continental glaciation and large deposits of stony moraine underlie surficial silty/sandy deposits. Soils are generally Orthic Humo-Ferric Podzols, although minor deposits of humified organic material are located in depressions and adjacent to lakes and streams. The area is heavily forested with boreal herb species and Sugar Maple, Yellow Birch, White Spruce and White Pine are the dominant tree species on well-drained sites. In moist low-lying areas, Sugar Maple, Red Maple, Black Ash and Eastern White Cedar dominate (Wickware and Cowell 1985).

The climate is generally cool and damp with a mean annual temperature of 3.3°C. The mean annual precipitation in the region is 1 123 mm. Annual loadings of wet sulphate in this area in 1980

averaged approximately 31 kg/ha/year with most of the watershed ranked as having a low potential to reduce the acidity of atmospheric depositions (Memorandum of Intent 1983).

Very little of the land in the region is in agricultural production. The main obstacles to agriculture are low temperatures, damp climate, thin and stony soils, adverse topography, and poor accessibility to markets. However, much of the region has been, or is at present being exploited for its forest reserves. Low-lying river valleys and accessible nearby slopes appear to be the most favourable for forestry production. Hence, much of the income in this region is derived from the forest industry.

The heavy vegetation cover, varied topography and plentiful lakes and streams serve to lure many anglers, hunters and hikers to the area. Although most organized resorts are small, and accessibility is poor, the area continues to see slow but constant growth of recreational land uses.

4.2.2 Establishment of Study Area

The Turkey Lakes Watershed was established to permit study of episodic acid shock events and the long term effects of acidic deposition on a hardwood forest ecosystem under a moderate acid precipitation loading regime. Included in the study is the intensive monitoring of lake and stream chemistry, biota, groundwater, runoff, vegetation effects, atmospheric quality and precipitation. Part of the research program was begun in the summer of 1980 with the ecological classification of forest ecosystems in terms of major forest vegetation, soil types and site characteristics (Wickware and Cowell 1985; Kusmirski and Cowell 1983).

Agencies involved in the establishment of the Turkey Lakes Watershed as a calibrated watershed were Fisheries and Oceans Canada; the Canadian Forestry Service; Environment Canada (Lands Directorate,

Inland Waters Directorate, and Atmospheric Environment Service); and the Ontario Ministry of Natural Resources.

Initial surveys to select a proper research watershed considered hundreds of potential sites. This was eventually narrowed to 12 watersheds which met the following site criteria:

1) an undisturbed ecosystem;
2) favourable accessibility from Sault Ste. Marie;
3) a chain of headwater lakes that were not heavily coloured by organics;
4) extensive Great Lakes hardwood forests;
5) steep slopes;
6) a variety of soils;
7) cool temperatures; and
8) plentiful precipitation.

The Turkey Lakes Watershed was chosen as the most suitable. The area was subsequently protected by agreement with the Ontario Ministry of Natural Resources so the natural habitat could be maintained and strictly managed. The site was felt to have relatively similar terrestrial, aquatic and atmospheric environments as other watersheds in the Algoma District. Historical land uses were not considered other than ensuring that the present ecosystem was largely undisturbed.

Currently, acid precipitation research at the TLW is concentrated on water quantity and water quality monitoring, groundwater studies, aquatic biology monitoring, and forest effects. University researchers involved cooperatively with government agencies or privately in the Turkey Lakes Watershed include those from Brock, Guelph, McMaster, Toronto and Queen's universities.

The Canadian Wildlife Service (CWS) considered the Turkey Lakes Watershed in 1980 as a possible research site to evaluate the effects of acid precipitation upon wildlife (mainly bird) habitats.

It was found that the lakes were too restricted and did not contain a large enough selection of wetlands for food-chain related research. The degree of experimentation in the watershed was also cited as a factor that would hinder the natural functioning of certain wildlife habitats. Hence, CWS initiated research in the Ranger Lakes area, 48 km to the east of the Turkey Lakes Watershed. Favourable factors included better accessibility, increased representativity (150 lakes covering 1 035 km^2), less local experimental interference, and a wider selection of pristine wetland habitats. More recently, the focus of some CWS studies is shifting from the Ranger Lakes area to the Sudbury region.

4.2.3 Watershed Description and Land Use History

The Turkey Lakes Watershed (lat. 47°03'N., long. 84°25'W.) is located between Norberg and Wishart Townships 60 kilometres north of Sault Ste. Marie, Ontario. The watershed contains five small lakes and open ponds which cover approximately 110 ha. The watershed encompasses 1 050 ha, although for the purpose of this study, areas outside the watershed boundaries have been included which increase the study area to 1 265 ha. The elevation of the study area ranges between 340 m and 630 m a.s.l. Figures 4 and 5 provide representative views of the watershed and a forest study site.

The watershed is on the Canadian Shield, with bedrock of Precambrian metamorphic origin (primarily greenstone) with smaller areas of granite. Surficial deposits in the watershed are comprised of sandy loam, silty loam and loamy silt. Organic material is found in several open fens and bogs. Large areas of stone, gravel and boulders are located within the watershed and much of this is underlain by a stony basal moraine.

Boreal herb species are common on north and west facing sites. Sugar Maple and Yellow Birch dominate the upland mineral soil sites with a minor component of White Spruce and White Pine present. Sugar Maple, Red Maple, Black Ash and White Cedar with a ground

Figure 4: Rolling terrain of the Turkey Lakes Watershed as viewed from local fire tower

Figure 5: Intensive forest plots are under study at the Turkey Lakes Watershed as well as other Canadian calibrated watersheds to evaluate short-term and long-term effects on forest ecosystems

cover of Sphagnum moss are found in wet areas. All tree stands in the watershed are relatively mature with ages estimated to be between 115-160 years old (Wickware and Cowell 1985).

The Turkey Lakes Watershed consists of five lakes. Batchawana Lake North is fed by one stream and has a surface area of approximately 6 ha. It is connected to Batchawana Lake South which is fed by three streams and covers 5 ha. Wishart Lake is 19 ha in area and is fed by five streams, while Little Turkey Lake, 20 ha, is fed by five streams one of which drains a 4 ha pond directly to the northeast. It is connected to Turkey Lake, covering 52 ha and is fed by six streams and drains a 4 ha basin located to the south. Turkey Lake drains to the northwest into the Batchawana River (Jeffries and Semkin 1982).

Land Use History

The data for the Turkey Lakes watershed was interpreted from 1937, 1961 and 1974 air photography. Winter photography taken in 1981 was found to be unsuitable for land activity/cover analysis. Summaries of the land use in each period are presented in Table 5 and detailed recorded changes for 1961-1974 are listed in Table B1 in Appendix B. No changes in land cover or land activity from 1937-1961 were noted. The percentages shown in Table B1 are the percentages of the original 1937 classes that have changed to other uses. The total change in hectares at the bottom of the table reflects the sum of all land uses (in hectares) that have changed to new classifications between 1937 and 1961.

1937 - The 1937 coverage showed the area to be relatively undisturbed by any man-influenced activity. Over 86% of the TLW was mature forest, while a mix of immature trees, shrubs and grasses covered 4.5% and low-lying wet areas containing ponds mixed with vegetation accounted for only 1%. No roads or logging development are visible near the watershed. The nearby Batchawana River valley also appeared to be

TABLE 5

TURKEY LAKES WATERSHED, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1937 Coverage		1961 Coverage		1974 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Trees/No Activity (W1/NO)	1 088.6	86.0	1 088.6	86.0	1 087.3	85.9
Water (ZO)	107.3	8.5	107.3	8.5	107.3	8.5
Trees, Grasses/No Activity (W1, V4/NO)	27.1	2.1	27.1	2.1	27.1	2.1
Sedges, Water/No Activity (V4, ZO/NO)	11.2	0.9	11.2	0.9	11.2	0.9
Shrubs/No Activity (W2/NO)	10.0	0.8	10.0	0.8	10.0	0.8
Grasses, Shrubs/No Activity (V4, W2/NO)	7.4	0.6	7.4	0.6	7.4	0.6
Shrubs, Trees/No Activity (W2, W1/NO)	6.7	0.5	6.7	0.5	6.7	0.5
Shrubs, Grasses/No Activity (W2, V4/NO)	2.6	0.2	2.6	0.2	2.6	0.2
Grasses, Trees/No Activity (V4, W1/NO)	1.4	0.1	1.4	0.1	1.4	0.1
Trees, Shrubs/No Activity (W1, W2/NO)	1.1	0.1	1.1	0.1	1.1	0.1
Shrubs, Water/No Activity (W2, ZO/NO)	0.8	0.1	0.8	0.1	0.8	0.1
Grasses/No Activity (V4/NO)	0.7	0.1	0.7	0.1	0.7	0.1
Trees, Water/No Activity (W1, ZO/NO)	0.7	0.1	0.7	0.1	0.7	0.1
Water, Grasses/No Activity (ZO, V4/NO)	0.2	-	0.2	-	0.2	-
Barren/No Activity (XO/NO)	0	0	0	0	1.3	0.1
Total Area	1 265.8 ha	100%	1 265.8 ha	100%	1 265.8 ha	100%

undisturbed and there is no visible evidence of forest fires.

1961 - In the period between 1937 and 1961, two well-maintained roads appeared off of the Batchawana River network and entered the watershed at the northwest boundary skirting the northern shorelines of Turkey and Little Turkey lakes and exited from the study area at the southeast boundary. A new road is observed running from the east boundary along the north shore of Wishart Lake. A parallel road was constructed to the southern tip of Batchawana Lake.

Many small car tracks and intermittent trails are visible on the 1961 photography. It is likely that they were being used for recreational access to the lakes. As well, small hiking trails are visible leading to the base of Batchawana Mountain; however, only the major trails have been examined in this study. There are many more faint trails that are discernable on fall photography, but these are too undefined to be recorded.

Although road construction occured between 1937-1961, the study area had not been the site of any recent logging or other large scale activities. The many small trails would indicate that the TLW was being heavily used for unorganized recreational activities. There were no changes in land cover/activity between 1937 and 1961 and all classes maintained the percentages they held in 1937.

1974 - The 1974 coverage reveals only minor changes. Many of the roads had been widened and extended. Rock cuts along the roads account for much of the change that occurred. Many of the intermittent tracks had been abandoned but a network of new trails and tracks spread throughout the watershed. Well-maintained road extensions were built to the north and west shore of Wishart Lake and the base of Batchawana

Mountain. A new small clearing (0.3 ha) is visible in the southwest of the TLW but no development is evident.

Other than the road network, the watershed remained much as it was in 1937. The 1974 photos reveal extensive logging throughout the nearby Batchawana River valley and up accessible slopes. High grade harvesting of White Pine, Spruce, Yellow Birch and some Maple had been undertaken in the area (G.M. Wickware, personal communication) but there is no physical evidence of this on any of the air photographs.

4.2.4 Regional Representativity

The Turkey Lakes Watershed area is largely representative of the region in which it is located. It has typical slope, soil, temperature and atmospheric conditions characterized by rugged glaciated landscapes of moraine and outwash features. It does not however, offer a wide variety of typical lakeshore or stream environments. It also lacks an abundance of boreal and conifer swamps common to the region. One of the deciding factors in favour of selecting the Turkey Lakes Watershed over other potential acid precipitation basins was its extensive Great Lakes hardwood forest. Under-abundance of boreal and conifer swamps was not viewed as a negative site selection element. The geology of the watershed is also slightly anomalous. Greenstone underlays the area, which is atypical of the predominant granite bedrock. This is viewed as having no major effect on the research currently being carried out (D.S. Jeffries, personal communication).

Taking the aforementioned geological and wetland anomalies into consideration, the Turkey Lakes Watershed is representative of the regions adjacent to the east shore of Lake Superior. The TLW offers a well-documented, relatively undisturbed natural environment in which to perform monitoring of long-term deposition and impacts of acid precipitation.

4.3 Dorset Study Area, Ontario

4.3.1 Regional Setting

The Dorset Study Area consists of eight small watersheds located in a 33 km^2 area of the Muskoka - Haliburton region of Ontario. The watersheds are located on the Canadian Shield, with igneous bedrock, mainly light-coloured acidic varieties such as granite or syenite. The region has been peneplaned; hence, short steep slopes are common with elevations in the watersheds generally between 300-450 m a.s.l.

The area is characterized by a thin covering of sandy morainal soils over bedrock. Rock exposures are common and soil thicknesses of more than 30-40 cm are rare. Where intermittent deep soil deposits do occur, they tend to be Podzolic sands. Level lacustrine plains and sandy outwash deposits are found between the rock outcrops and small lakes and bogs are numerous. Well-drained silty loam soils on irregular slopes exist around some of the lakes and in river valleys.

Much of the Dorset area is heavily forested with Sugar Maple, Silver Birch, Yellow Birch, White Pine, Red Pine and Basswood being the dominant tree species on well-drained sites. In moist areas Elm, Ash, Tamarack, Spruce and Cedar dominate.

The regional climate is generally cool and moderately humid with a mean annual temperature of 3°C, making it one of the coldest and shortest growing seasons in southern Ontario. The mean annual precipitation is 890 mm. In 1980 the Dorset region received a mean annual wet sulphate deposition of, approximately 33 kg/ha/yr a level considered to have a high potential for major aquatic impact. Most of the region is mapped as having a low potential to reduce acidic deposition as rated by the MOI evaluation (Memorandum of Intent 1983).

On a regional basis, six percent of the land is in agricultural production, with the area of occupied farmland decreasing annually. The main obstacles to agriculture are the climate and soil capability. The Canada Land Inventory rated all the soils in the watershed areas as class 7 indicating severe limitations for agriculture. Stones interfere with tillage, planting and harvesting and bedrock is less than one metre from the surface (Hoffman 1967).

The varied topography, dense vegetation and existence of small lakes and streams draw many tourists to the area. As cottage development has begun to surround many of the lakes, the region has become known as a recreation and summer resort area.

4.3.2 Establishment of Study Area

The Dorset Study Area has been the focus of a number of recent research projects. In 1976, the Ontario Ministry of the Environment, Water Resources Branch, with funding from the Ontario Ministry of Housing, initiated the Lakeshore Capacity Study. Eight lakes in the Dorset area were chosen for research to form a set of province-wide data bases to aid in the establishment of public policy on further land development in areas such as Muskoka. Gauging stations were established at sites along 42 streams until monitoring redesign reduced this to 32 streams in 1980. The chemistry of water intakes, and losses and the mass flow of nutrients were monitored throughout the area. The main intent of the study was to monitor the phosphorous content of lake water caused by pollutants from septic beds.

Factors considered in identifying sites which best resembled the regional phosphorus variation included: contrasts in trees and other vegetation types, and a mix of naturally acidic and clear headwater lakes, and varying cottage densities covering a wide spectrum of septic field input.

In 1980 the Dorset watersheds became part of the national calibrated watershed network when the Acid Precipitation in Ontario Study (APIOS) began working within the watersheds. Initial APIOS research was carried out at Plastic Lake. The Plastic Lake watershed is entirely located on provincially-owned land and therefore researchers had a controlled environment for management of the natural resources. In 1982 terrestrial research on two of the watersheds commenced under contract to the University of Toronto Forestry Faculty with funding from the Ontario Ministry of the Environment (Schneider et al. 1983).

The criteria used in choosing the Dorset sites for acid precipitation studies included:

1) watersheds with isolated headwaters;
2) contrasting terrestrial environments and water chemistry make-up;
3) good site accessibility;
4) constant atmospheric conditions across all monitored watersheds;
5) land tenure that was unlikely to produce major land development;
6) geological, terrestrial and aquatic data sets existed; and
7) relative similarity of the watersheds with the rest of the Muskoka region.

Historical land uses were not considered when establishing site criteria other than noting that much of the area was second growth hardwood due to logging.

Currently, detailed vegetation and soil reports are being prepared for the individual watersheds. The Ontario Ministry of the Environment, the Ontario Ministry of Natural Resources, Environment Canada, Fisheries and Oceans Canada, and approximately 20 researchers from 7 universities are carrying out research on 30 studies within these watersheds. Much of the work is funded by the participating agencies or researchers.

4.3.3 Individual Watershed Descriptions and Land Use Histories

4.3.3a Plastic Lake

Plastic Lake (lat. 45°11'N., long. 78°50'W.) is located in the Leslie M. Frost Natural Resource Centre in Sherborne Township, Haliburton County. The lake is a small (32.2 ha) Canadian Shield headwater lake (Figure 6). The watershed is covered by a discontinuous, thin layer of basal moraine. Gneissic bedrock is exposed in many parts of the watershed. Some organic deposition is occurring in bog areas and weakly developed soils are evident overlying the thin basal deposits.

The forest is dominated by coniferous trees, commonly White Pine and Hemlock. Maple and Birch hardwoods are evident on steep slopes with deeper basal deposits. Bogs are vegetated mainly with Black Spruce.

The Plastic Lake watershed contains only one small open-water pond. The land rises steeply from the water surface with no point in the watershed being greater than one kilometre from the lake. The lake is fed from one perennial stream and four ephemeral streams (Girard et al. 1985).

Land Use History

The map base of the watershed and surrounding area encompasses 193 ha. Air photo coverages from 1935, 1969 and 1981 were used. Table 6 indicates the land uses for each of the study years. Table B2 in Appendix B presents in detail the change in land use from 1935 to 1969. No changes from 1969-1981 were recorded.

1935 - There was no perceived land activity. An immature/mature forest mix dominated the land cover, totalling 74% of the land area. Shrubs, grass, sedges and low-lying moist areas made up the rest of the area. Although logging operations

Figure 6: Plastic Lake study area, Ontario

TABLE 6

PLASTIC LAKE, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1935 Coverage		1969 Coverage		1981 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1,/NO)	143.1	73.9	144.1	74.5	144.1	74.5
Water (ZO)	37.1	19.2	37.1	19.2	37.1	19.2
Shrubs, Sedges/No Activity (W2, V4/NO)	7.8	4.0	7.5	3.9	7.5	3.9
Sedges, Grasses, Shrubs/ No Activity (V4, W2/NO)	2.9	1.5	2.2	1.1	2.2	1.1
Shrubs/No Activity (W2/NO)	1.9	1.0	1.9	1.0	1.9	1.0
Sedges/No Activity (V4/NO)	0.6	0.3	0.6	0.3	0.6	0.3
Total Area	193.4 ha	100%	193.4 ha	100%	193.4 ha	100%

did take place in the region around the turn of the century there is no strong visible evidence of this in the 1935 air photography.

1969 - The land uses in the Plastic Lake study area had changed little since 1935. Only minor natural growth changes occurred around bog areas by 1969. A well-maintained road was constructed skirting the west edge of the lake but no further development was obvious.

1981 - Virtually no changes occurred in land use from 1969 to 1981. A small intermittent track had been cut off the main road. A small portion of intermittent track cut between 1935-1969 appears to have been abandoned.

4.3.3b Dickie and Heney Lakes

Dickie and Heney Lakes (lat. 45°09'N., long 79°05'W.) are located approximately 21 km southeast of Huntsville, Ontario in MacLean Township. These two watersheds have been combined for mapping and land use calculations due to their close proximity. Dickie Lake is a medium sized Canadian Shield headwater lake of approximately 100 ha. Seven small streams drain the basin into the lake. The watershed area is dominated by peat bogs overlying shallow, sandy deposits and surrounded by extensive areas of thin moraine and rock ridges. In places the thin moraine and peat overlie layers of clay and sand. The bedrock geology throughout the watershed is Precambrian hornblende migmatite.

Poor drainage in low-lying areas has resulted in the presence of Sphagnum bogs surrounded by stands of Hemlock, Balsam Fir and isolated Black Spruce. Hardwood forest is dominant on morainal deposits although local stands of White Pine can be found near bedrock outcrops.

Heney Lake is also a small Canadian Shield headwater lake. The watershed is small and covered by a thin layer of modified basal moraine. The bedrock throughout the watershed is migmatite. Organic deposition is occurring in the watershed bog areas and soils are weakly developed Podzols and Brunisols. Silt and fine sand underlie peat bogs adjacent to the lake.

The bog areas are dominated by Black Spruce or Alder while other conifers dominate the remainder of the watershed. Hardwoods are found on those upland areas having slightly deeper overburden. The watershed drains into the lake via two perennial streams. No open ponds are found within the watershed boundaries (Girard et al. 1985).

Land Use History

The mapped area of the Dickie and Heney lakes watersheds and the surrounding area encompasses 1 497 ha using 1935, 1971 and 1983 air photography.

The southwest portion of the 1935 coverage is unclassified due to air photo gaps. The land uses for each study period are summarized in Table 7 with detailed change data presented in Tables B3 and B4 of Appendix B.

1935 - Unexploited forest and shrubland were the dominant classes covering approximately 72% of the study area. Agricultural activities accounted for 5.7% of the study area and abandoned forestry activities 2%. Minor cottage development occupied the northeast shore of Dickie Lake with four cottages discernible in the 1935 air photos. The only well-developed road ran east/west across farmland at the north end of Dickie Lake. Intermittent trails are visible at the south end of Dickie Lake connecting areas of farmland separated by forest. Abandoned trails (possibly old forestry roads) ran through the forested area just east of Dickie Lake.

TABLE 7

DICKIE AND HENEY LAKES, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1935 Coverage		1971 Coverage		1983 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1/NO)	726.9	48.6	852.6	57.0	866.6	57.9
Trees, Shrubs/No Activity (W1, W2/NO)	240.4	16.1	234.2	15.6	234.2	15.6
Water (ZO)	142.6	9.5	142.6	9.5	142.5	9.5
Shrubs, Grasses/No Activity (W2, V4/NO)	83.7	5.6	105.4	7.0	99.2	6.6
Shrubs, Grasses/Grazing (W2, V4/A1)	39.2	2.6	0	0	0	0
Grassland/Grazing (V3/A1)	32.8	2.2	15.3	1.0	15.2	1.0
Shrubs, Grasses/Abandoned Forest (W2, V4/B2)	30.9	2.0	0	0	0	0
Grasses, Shrubs/Grazing (V4, W2/A1)	13.8	0.9	0	0	0	0
Grasses, Shrubs/No Activity (V4, W2/NO)	6.4	0.4	4.8	0.3	4.8	0.3
Shrubs/No Activity (W2/NO)	5.8	0.4	3.7	0.2	10.0	0.7
Grasses/No Activity (V4/NO)	5.5	0.4	6.2	0.4	6.2	0.4
Grasses, Build-Up/Grazing, Dwelling (V4, YO/A1, DO)	2.7	0.2	3.7	0.2	3.7	0.2
Shrubs, Built-Up/Recreation, Cottage (W2, YO/R1, DO)	1.9	0.1	61.5	4.1	68.5	4.6
Grasses/Grazing (V4/A1)	1.4	0.1	1.4	0.1	1.4	0.1
Grasses, Built-Up/Grazing, Orchard (V4, YO/A1, A2)	0.2	-	0	0	0	0
Shrubs, Trees/Abandoned Agriculture (W2, W1/B1)	0	0	13.7	0.9	13.7	0.9
Built-Up, Grasses/Dwelling (YO, V4/DO)	0	0	0.3	-	0.7	0.1
Shrubs, Grasses/Abandoned Agriculture (W2, V4/B1)	0	0	28.7	1.9	7.4	0.5
Trees, Shrubs/Abandoned Agriculture (W1, W2/B1)	0	0	22.9	1.5	22.9	1.5
Unclassified (08)	162.8	10.9	0	0	0	0
Total Area	1 497.0 ha	100%	1 497.0 ha	100%	1 497.0 ha	100%

1971 - Significant land use change occured on 12% of this study area from 1935-1971. The major man-made change in the 1971 coverage was the increase in cottages around Dickie and Heney lakes. Land used for cottages increased to 4.1% of the total land area primarily from land classed as "no perceived activity" in immature/mature forests. Both Dickie and Heney lakeshores were the sites of well-developed roads serving the cottage areas. Almost all of the abandoned forestry sites had reverted to mature forest. Agricultural activities decreased from 5.7% to 1.4% of the area by 1971, while abandoned farmland increased from 0% to 4.3%. Some intermittent trails were developed on previously abandoned roads northwest of Dickie Lake. A previously unclassified trail running east from the north shore of Dickie Lake lies abandoned in 1971.

1983 - Although the area of active agriculture land did not change from 1971, 74% of the abandoned agricultural land reverted to forest cover, making it the dominant 1971-1983 change out of a total change of just 3.2% of the watershed. The second major land use change was the continued loss of forested land (7 ha) to cottage development around Dickie Lake. Very few other man-made changes have taken place other than the development of isolated residences along the east/west highway at the north end of Dickie Lake.

4.3.3c Chub Lake

Chub Lake (lat. 45°09'N., long. 78°57'W.) is located in the Muskoka District 22.5 km southeast of Huntsville, Ontario. It is a small Canadian Shield headwater lake fed by eight small streams. The bedrock throughout the watershed and the surrounding study area is granitized biotite gneiss. About 62% of the area northwest and south of the lake is covered by a combination of thin morainal deposits and exposed rock ridges, while 32% of the region immediately west and north of the lake is dominated by a minor

morainal plain. Seven small deposits of peat over bedrock and very minor occurrences of exposed bedrock account for the rest of the watershed.

The dominant forest cover on the thin moraine and rock ridges is a mix of Yellow Birch, Balsam Poplar and White Pine. Maple dominates the plains to the north and east of the lake while peat areas have a mixture of low shrubs and mosses (Jeffries and Synder 1983).

Land Use History

The mapped area of the Chub Lake watershed and surrounding area encompass 644 ha of land, with interpretations derived from 1935, 1969 and 1981 air photographs. A summary of major land activity and cover in each of these periods is given in Table 8. The Chub Lake area underwent little change between 1935-1981 as summarized in Tables B5 and B6 in Appendix B.

1935 - In 1935 forest and scrub covered 83.4% of the watershed; agricultural activities covered 3.3% of the area, and abandoned agricultural land accounted for 7.1%. Two well-developed roads located north and south of the lake ran east/west along discontinuous strips of active and abandoned agricultural land. Abandoned trails linked areas of abandoned agriculture north and east of Chub Lake.

1969 - A total of 82.2 ha, 13% of the watershed, changed classification between 1935 and 1969. The largest change was 32.5 ha of abandoned agricultural land reverting to forested cover. Over 95% of the area classified as abandoned agriculture in 1935 reverted to heavily vegetated classifications by 1969. As a result, forest and shrub cover increased from 74.4% to 81.7% of the land area. Active agricultural land decreased from 3.3% to less than 0.1%. A new road was constructed from the highway in the southern end of the study area north to the edge of the

TABLE 8

CHUB LAKE, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1935 Coverage		1969 Coverage		1981 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1/NO)	278.5	43.2	316.6	49.1	322.4	50.1
Trees, Shrubs/No Activity (W1, W2/NO)	201.6	31.3	201.6	31.3	201.6	31.3
Shrubs, Grasses/Abandoned Agriculture (W2, V4/B1)	45.6	7.1	22.1	3.4	16.5	2.6
Water (ZO)	39.2	6.1	39.2	6.1	39.2	6.1
Shrubs, Grasses/No Activity (W2, V4/NO)	29.5	4.6	42.7	6.6	42.1	6.5
Trees, Grasses/No Activity (W1, V4/NO)	18.3	2.8	8.7	1.4	8.7	1.4
Shrubs, Grasses/Grazing (W2, V4/A1)	11.7	1.8	0	0	0	0
Grasses/No Activity (V4/NO)	6.4	1.0	6.4	1.0	6.4	1.0
Grasses, Shrubs/Grazing (V4, W2/A1)	5.5	0.9	0	0	0	0
Grasses, Shrubs/No Activity (V4, W2/NO)	3.3	0.5	1.2	0.2	1.2	0.2
Grassland/Grazing (V3/A1)	2.9	0.5	0.8	0.1	0	0
Grass, Built-Up/Grazing (V4, YO/A1)	1.2	0.2	0	0	0	0
Grass, Built-Up/Farm (V4, YO/A4)	0.4	0.1	0	0	0	0
Built-Up, Grass/Dwelling (YO, V4/DO)	0.1	-	0.1	-	0.1	-
Shrubs, Trees/Abandoned Agriculture (W2, W1/B1)	0	0	3.4	0.5	3.5	0.5
Shrubs/No Activity (W2/NO)	0	0	1.4	0.2	2.5	0.4
Total Area	644.2 ha	100%	644.2 ha	100%	644.2 ha	100%

lake. A new small road is also visible running from the same highway north to the heavily forested area west of the lake.

1981 - Only 1% of the land in the watershed changed classification between 1969 and 1981. A small area (5.9 ha) of abandoned farmland reverted to forest cover and all active agricultural land ceased to exist by 1981. Two small trails in the south of the study area were also abandoned.

4.3.3d Blue and Red Chalk Lakes

Blue Chalk Lake (lat. 45°12'N., long. 78°56'W.) is a small Canadian Shield headwater lake in the Muskoka District 26 km southeast of Huntsville, Ontario (Figure 7). The lake is fed by a single stream at the northeast corner of the lake. Blue Chalk Lake drains via a short stream south into Red Chalk Lake which, in turn, is fed by four streams draining six small ponds in the watershed. Due to Red and Blue Chalk Lakes' close proximity to each other, both have been considered as one study area in this analysis.

The bedrock underlying both watersheds is granitized biotite gneiss. There is a major, level deposit of poorly-sorted, cobbly outwash mixed with sand and gravel on the shores of Red Chalk Lake, with smaller deposits occurring along Blue Chalk Lake. A morainal plain covers much of the bedrock throughout both watersheds. Narrow ribbons of shallow moraine and rocky ridges dominate the northern and southeast shorelines of Blue Chalk Lake. Larger deposits of the same materials are evident on the southeast and west shorelines of Red Chalk Lake. This lake has a large exposure of bedrock directly to the east, and a number of peat bogs are present in its watershed.

White Pine and Birch are the most common tree species growing on the outwash sand and gravel. Hardwoods form the majority of the vegetation on the morainal plain with mosses and small shrubs visible around the ponded waters (Jeffries and Snyder 1983).

Figure 7: Blue Chalk Lake study area, Ontario

Land Use History

The mapped area of the Red and Blue Chalk lakes watersheds and the surrounding area cover 1 251 ha. Air photographs from 1935, 1969 and 1981 were used to compile the data which is summarized for each period in Table 9. Land use changes are detailed in Tables B7 and B8 in Appendix B. These watersheds remained essentially unchanged from 1935-1981.

1935 - The watersheds of Blue and Red Chalk Lakes had been largely unaltered by man's activities up to 1935. A few scattered trails lead to two lodges, one on Blue Chalk Lake and the other on Red Chalk Lake. The lodges and their grounds accounted for only 0.1% of the land area. Heavily forested cover accounted for 85.0% of the study area while shrub, grasses, and sedges occupied 3.7%.

1969 - Land use altered very little between 1935 and 1969 with only 1.7 ha changing classification. A well-developed access road to the northern tip of Blue Chalk Lake had been constructed by 1969. A few scattered cottages had been built where the road meets the lake and a lone cottage built on the north shore of Blue Chalk Lake with boat access only. A larger lodge appeared on the northwest shoreline of Red Chalk Lake and a small track linked it with an existing trail. A larger portion of the intermittent tracks in the northwest section had been abandoned. New trails had sprung up around the northeast shore of Blue Chalk Lake and the southeast shore of Red Chalk Lake.

1981 - Further minor cottage development occurred on the northern tip of Blue Chalk Lake and a road extension was built to facilitate access. The trails that had linked the lodge on the northeast shore of Blue Chalk Lake with a road outside the northern boundary of the study area had been abandoned. The total change in these watersheds from 1969-81 was 0.4 ha.

TABLE 9

BLUE CHALK AND RED CHALK LAKES, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1935 Coverage		1969 Coverage		1981 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Trees, Shrubs/No Activity (W1, W2/NO)	711.0	56.8	711.0	56.8	711.0	56.8
Shrubs, Trees/No Activity (W2, W1/NO)	320.1	25.6	318.4	25.4	318.0	25.4
Water (ZO)	141.0	11.3	141.0	11.3	141.0	11.3
Grasses, Shrubs/No Activity (W2, V4/NO	45.8	3.7	45.8	3.7	45.7	3.7
Shrubs/No Activity (W2/NO)	23.4	1.9	23.4	1.9	23.3	1.9
Shrubs, Barren/No Activity (W2, XO/NO)	7.5	0.6	7.5	0.6	7.3	0.6
Shrubs, Grasses/No Activity (W2, V4/NO	2.0	0.2	2.0	0.2	2.0	0.2
Shrubs, Built-Up/Recreation, Cottage (W2, YO/R1, DO)	0.6	0.1	2.3	0.2	2.7	0.2
Grasses/No Activity (V4/NO)	0.4	-	0.4	-	0.4	-
Total Area	1 251.8 ha	100%	1 251.8 ha	100%	1 251.8 ha	100%

4.3.3e Harp and Jerry Lakes

Harp and Jerry Lakes (lat. 45°22'N., long. 70°08'W.) are two headwater lakes located on the Canadian Shield in the Muskoka District 9 km northeast of Huntsville, Ontario. Harp Lake is fed by eight streams one of which drains a large open pond. The bedrock to the east of the lake is amphibolite and schist. To the north, east and south, biotite granite and hornblende gneiss compose the bedrock. The bedrock to the southeast of Harp Lake is diorite.

The surficial geology of the Harp Lake watershed is quite complex. The eastern, western and northern boundaries of the watershed are covered by thin moraine and exposed rock ridges. The areas directly south, west and north of the Lake are covered by a localized morainal plain broken by extensive 15 metre deep deposits of well-sorted sand and small pockets of peat over sand. Three large deposits of peat over sand exist to the north and northeast of the Lake.

Jerry Lake is fed by six streams, one of which drains an open pond. The watershed bedrock is dominated by biotite granite and hornblende gneiss, with a small area of diorite directly to the west.

Much of the land northeast, east and southeast of the watershed is covered by a thin morainal veneer with rock ridges broken only by small pockets of peat over sand, peat over moraine, exposed bedrock and morainal plain. Directly northeast of the lake is a large sandy delta-raised beach complex rising 10 m above the shoreline. Large deposits of peat over sand exist to the north and northeast of Jerry Lake. To the north and west of the Lake is a morainal plain interrupted by a ribbon of thin, sandy deposits, rock ridges, and small areas of peat over sand and peat over moraine.

Mature hardwoods are generally present throughout both watersheds where thin moraine exists. Maple tends to be associated with moraines and White Pine with sand deposits. Hemlock, Balsam Fir, Black Spruce and mosses occur in peaty areas.

Land Use History

Due to the close proximity of Harp and Jerry Lakes to each other, both watersheds are combined for the purposes of this analysis. The mapped area for the two watersheds and their surrounding areas encompass 2 496 ha. The air photo coverages used to compile the data are from 1935, 1969 and 1983 with the summary of land use in each period presented in Table 10.

The Harp and Jerry lakes study area echos many of the trends of the other Dorset watersheds. Active agriculture has decreased, creating abandoned agricultural land. As time progresses, the abandoned land is reverting to natural covers. Recreational use of land around the lakes is increasing, especially in areas that are heavily forested. Land use changes from 1935-1969 and 1969-1983 are summarized in Tables B9 and B10 in Appendix B.

1935 - Forest and bush were the dominant covers, occupying 83.6% of the study area. Active agricultural uses accounted for 8.2% while abandoned agricultural land covered 1.2%. Much of the abandoned farmland existed on the east shore of Jerry Lake. There was no active forestry occurring in either watershed; however, 1.2% of the area is tentatively interpreted as mature, abandoned forestry cover. This is most evident on the southwest shoreline of Harp Lake. No recreational land uses were evident and no well-developed roads lead to either lake. The northwest and east sections of the study area had a well-maintained road network. The central area of these two watersheds had overgrown, intermittent trails and car tracks.

1969 - Land use classification changed on 459.4 ha, 18% of the two watersheds, between 1935 and 1969. The bulk of the change was in natural cover classes evolving to more mature states. This suggests that either the 1935 figure of 1.2% for abandoned forestry is too low or else they are old burn

TABLE 10

HARP AND JERRY LAKES, ONTARIO, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1935 Coverage		1969 Coverage		1983 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1/N0)	1 021.0	40.9	984.9	39.4	1 023.0	41.0
Trees, Shrubs/No Activity (W1, W2/N0)	815.7	32.7	904.9	36.2	884.7	35.4
Water (Z0)	144.8	5.8	134.9	5.4	134.9	5.4
Shrubs, Grasses/No Activity (W2, V4/N0)	107.6	4.3	108.2	4.3	125.1	5.0
Grasses, Shrubs/Grazing (V4, W2/A1)	76.5	3.1	12.4	0.5	1.2	0.1
Grassland/Grazing (V3/A1)	75.9	3.0	24.7	1.0	1.1	-
Shrubs/No Activity (W2/N0)	71.2	2.9	84.6	3.4	131.6	5.3
Grasses, Shrubs/No Activity (V4, W2/N0)	44.2	1.8	4.8	0.2	4.8	0.2
Shrubs, Grasses/Grazing (W2, V4/A1)	33.5	1.3	9.5	0.4	18.2	0.7
Shrubs, Trees/Abandoned Forestry (W2, W1/B2)	29.1	1.2	0	0	0	0
Grasses, Shrubs/Abandoned Agriculture (V4, W2/B1)	25.6	1.0	16.2	0.6	0.8	-
Trees, Grasses/No Activity (W1,V4/N0)	14.8	0.6	14.8	0.6	14.8	0.6
Grasses/Grazing (V4/A1)	10.6	0.4	0	0	0	0
Grasses/No Activity (V4/N0)	9.3	0.4	6.6	0.3	6.6	0.3
Crops/Tillage (V2/A1)	7.6	0.3	0	0	0	0
Shrubs, Grasses/Abandoned Agriculture (W2, V4/B1)	3.9	0.2	80.5	3.2	21.0	0.8
Water, Sedges/No Activity (Z0, V4/N0)	3.2	0.1	3.2	0.1	3.2	0.1
Sedges, Built-Up/Tillage, Berries (V4, Y0/A1, A2)	1.3	0.1	0	0	0	0
Grasses, Built-Up/Tillage, Dwelling (V4, Y0/A1, D0)	0.5	-	0.7	-	0.6	-
Grasses, Built-Up/Tillage (V4, Y0/A1)	0.3	-	0	0	0	0
Built-Up/No Activity (Y0/N0)	0.1	-	0	0	0	0
Grasses, Built-Up/Farm (V4, Y0/A4)	0.1	-	0	0	0	0
Shrubs, Built-Up/Cottages (W2, Y0/R1, D0)	0	0	35.8	1.4	51.2	2.0
Shrubs/Abandoned Agriculture (W2/B1)	0	0	35.2	1.4	18.4	0.7
Shrubs, Water/No Activity (W2, Z0/N0)	0	0	10.6	0.4	10.6	0.4
Shrubs, Trees/Abandoned Agriculture (W2, W1/B1)	0	0	24.3	1.0	20.0	0.8
Grasses, Shrubs/Abandoned Forestry (V4, W2/B2)	0	0	0	0	13.1	0.5
Shrubs, Grasses/Abandoned Forestry (W2, V4/B2)	0	0	0	0	10.6	0.4
Built-Up, Grasses/Dwelling (Y0, V4/D0)	0	0	0	0	0.9	-
Grasses/Abandoned Forestry (V4/B2)	0	0	0	0	0.4	-
Total Area	2 496.8 ha	100%	2 496.8 ha	100%	2 496.8 ha	100%

areas. Although little abandoned forestry was evident in 1935 (air photography clarity notwithstanding), the 1969 percentages suggest that parts of the study area had been extensively logged well in advance of the 1935 coverage.

Forest and shrub cover totalled 84.8% in 1969 and active agricultural land had decreased to only 1.8% of the study area. Abandoned agricultural cover had increased to 6.2% while virtually all abandoned forestry land had reverted to mature forest cover. A significant area of recreational (cottage) land (35.9 ha) had appeared by 1969 although it is still represented less than 1% of the study area. A large portion of this is located around Harp Lake which was almost completely ringed by cottage development by 1969. This trend also occurred around a lake southeast of Jerry Lake, but Jerry Lake itself remained undeveloped.

Many small tracks and trails linking old farmsteads had been abandoned by 1969. Harp Lake was the site of a large road network which followed the shoreline and ran both north and south of the lake to major highways. The lake situated southeast of Jerry Lake also had a well-maintained road established leading to the cottage areas on its east shore.

1983 - During the 1969-1983 period, 195.7 ha (8% of these two watersheds) changed classification. The 1983 coverage solidifies the trends already noted in the previous years. Forested land and shrub had increased to 88.3% of the study area. Active agricultural land had fallen to 0.8%. Abandoned agricultural land took up 2.4% of the study area with much of the previously abandoned land reverting to natural cover with no perceived activity. Abandoned forestry land had increased to 0.9% of the study area. The north end of Harp Lake had seen some forestry activity and a small road was constructed to the site. Due to the absence of any cottage construction, the relative steepness of

slopes, and the distance of the site from the lake, it is unclear as to whether this land was cleared for recreational use. Harp Lake had cottage construction on its east shoreline and the lake east of Jerry Lake was also the site of extensive cottage and road building activity around its north, west and southeast shoreline. This trend had pushed the total area of recreational land to 51.2 ha, 2% of the watersheds, an increase of over 15 ha since 1969.

Road abandonment continued in the old farmland areas in the northwest section of the study area, where much of the former agricultural land had reverted to natural cover. The same phenomenon existed along the eastern border of the two watersheds study area.

4.3.4 Regional Representativity

The eight Dorset watersheds appear to be influenced by land use trends that are similar to regional trends occurring throughout the Muskoka District. The abandonment of the agricultural base is a well-established trend which was strongly evident even in the 1935 coverages, as is the case with the forest industry. Based upon the maturing of the forested cover from the 1930's to the 1970's, it is likely that extensive forestry in these watersheds was last practiced well-in-advance of the earliest available photography. These two combined abandonment phenomena have led to an increase in the area of maturing vegetation throughout the study areas.

The late 1960's and early 1970's saw the construction of well-maintained access roads opening up many of the study lakes and nearby lakes to recreational cottage use. In its early phase, development around the lakes was discontinuous. However, the early 1980's photography shows uninterrupted cottage development expanding outward around most lakes where the terrain, accessibility and land tenure were favourable. It is likely that lacking any constraints, recreational land uses (although modest in terms of spatial

coverage) could become the dominant land activity in many of the study watersheds.

The individual descriptions of the bedrock geology, surficial deposits, topography and vegetation cover of each watershed study area generally parallel available regional descriptions. Only a few nearby sedimentary watersheds with dolomite are not represented by the eight study areas, but these watersheds themselves tend to have characteristics that are atypical of the region (P.J. Dillon, personal communication). The differences in environments found in each of the eight watersheds assures that the study areas offer a regionally representative data base for acid precipitation monitoring. The Dorset Study area provides the opportunity to monitor eight varied watershed environments influenced by similar land use trends under comparable atmospheric loadings.

4.4 Lac Laflamme Study Area, Quebec

4.4.1 Regional Setting

The region is north of the St. Lawrence River in the Laurentian Highland. The Highlands are composed of Precambrian gneiss, anorthosite and some gabbro, expressed as a mountainous plateau dissected by narrow steep valleys. Elevations range from 396 m to 823 m a.s.l. with a strongly rolling landscape that drops abruptly toward the St. Lawrence River. Laurentides Provincial Park, with a mean elevation of 914 m a.s.l., occupies a large portion of the Highland. Soils on the Highland range from stony to sandy loam textured Podzols, derived from morainal deposits of various depths.

The region is a transitional zone between the northern clay section of the boreal forests north of the St. Lawrence and the Great Lakes-St. Lawrence forest to the south. Stands of Yellow Birch, Maple and Black and White Spruce characterize the region. White Birch and Yellow Birch are most common in the north, while Yellow Birch and Balsam Fir occur in the south. Most of the economy of the area is

dependent on the cutting of timber for pulpwood (Carrier and Rochefort 1971).

The region has a continental climate with a mean annual temperature of less than -3°C. Annual precipitation ranges between 685 and 1 016 mm.

Land used for agricultural production is located on isolated portions of the Highland where the terrain has deeper soils with shallower slopes and fewer stones. The soil capabilities rated in the Canada Land Inventory for agriculture are Class 7 with adverse topography, stoniness and thin soils as limiting factors.

4.4.2 Establishment of Study Area

The Lac Laflamme study area occupies a small portion of the Montmorency Forest Reserve in Laurentides Provincial Park, Quebec. In 1959-60 the provincial government granted a 99 year lease to Laval University for the Montmorency Experimental Forest. Research was to be conducted within the area by the Laval Faculties of Forestry and Geophysics, and the Laurentian Forest Research Centre of the Canadian Forestry Service. The Lac Laflamme Watershed was set aside as a forest reserve.

From the outset research has centred on regional forest management and the management and monitoring of fish in many of the small lakes that dot the Highland area. Later, studies in the Reserve included climatic monitoring and geological surveys.

The criteria used for selecting this research basin for acid precipitation monitoring over other sites included:

1) extensive boreal forest cover throughout the basin;
2) a level of deposition suitable for research purposes;
3) accessibility of the site by road;
4) headwater lake status;

5) a small manageable drainage basin for mass balance and outflow studies;
6) restricted use of the study area from the standpoint of current recreation and logging activities; and
7) ready accessibility to the support infrastructure available at the Laval University Forest Faculty.

Currently, the Canadian Forestry Service, the Inland Waters Directorate of Environment Canada, Fisheries and Oceans Canada, the University of Quebec, the Laval University Faculty of Forestry, and the Laval University Faculty of Geophysics are conducting studies at the site. Future research will include: closer monitoring of nitrogen and sulphur cycles; spring-melt studies; ozone, cloud and fog chemistry studies; and a proposed 1988 re-monitoring of all biophysical elements within the watershed.

4.4.3 Watershed Description and Land Use History

The Lac Laflamme Watershed (lat. 47°19'N., long. 71°07'W.) is located approximately 80 kilometres north of Quebec City, Quebec within the county of Montmorency #1.

The study area contains one small lake and no open ponds. The lake is a Canadian Shield headwater lake fed by an intermittent stream and drained by a small outlet (Figure 8). The area mapped for this project, including some minor areas outside the drainage basin, encompasses 494.3 ha.

The elevation of the study area ranges from 655 m a.s.l. at the Montmorency River on the west boundary, to 945 m a.s.l. near the northeast boundary. The steep rolling topography is typical of much of the Laurentian Highland. The bedrock consists primarily of charnockitic gneiss and mangerite covered with unconsolidated surficial deposits of gravel mixed with sand and a small percentage of silt. Soils are dominated by Orthic Humo-Ferric Podzols.

Figure 8: Lac Laflamme Watershed, Quebec

The watershed has a mean annual temperature of 0.2°C and 1 430 mm of precipitation annually (Papineau 1984). Annual loadings of wet sulphate in this area for 1980 averaged 44 kg/ha/yr with most of the area rated as having a poor potential for soils and bedrock to reduce the acidity of acidic depositions (Memorandum of Intent 1983, Li 1985).

The entire watershed area has been extensively logged during two periods (late 1800's and 1940's). Natural tree regeneration has resulted in a boreal forest makeup of 80% Balsam Fir, 10% White Spruce and 10% Birch. Wetland areas around the shores of Lac Laflamme support small stands of Black Spruce.

Land Use History

The data base of the Lac Laflamme watershed and surrounding area encompasses 494.3 ha. Air photographs for 1927, 1950 and 1974 were used to compile the three coverages, as summarized in Table 11. Change data for 1927-1950 and 1950-1974 are documented in Tables B11 and B12 in Appendix B.

1927 - There is little evidence on the 1927 photography of previous forestry activity. However, documentation indicates that most of the region had been selectively logged for mature Spruce in the late 1800's and early 1900's (J. Pkalgraph, personal communication).

Mature forest covered 79.1% of the study area with 18.5% of the watershed a mixture of immature forest and shrub in 1927. The immature forest appears to encompass areas too large to be the result of excessive soil moisture. In addition the location of this cover type on accessible slopes as well as depressed and level areas suggests that the immature forests have regenerated from selective forestry activity which occurred well in advance of the 1927 photography. Much of the watershed had regenerated to

TABLE 11

LAC LAFLAMME STUDY AREA, QUEBEC, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1927 Coverage		1950 Coverage		1974 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1/NO)	387.9	78.5	105.2	21.3	452.9	91.6
Shrubs/No Activity (W2/NO)	72.3	14.6	26.7	5.4	15.1	3.0
Water (ZO)	10.2	2.1	10.2	2.1	10.2	2.1
Grasses, Shrubs/No Activity (V4, W2/NO)	8.0	1.6	0	0	0	0
Shrubs, Grasses/No Activity (W2, V4/NO)	7.5	1.5	0.3	0.1	6.0	1.2
Trees, Grasses/No Activity (W1, V4/NO)	3.3	0.7	3.3	0.7	3.3	0.7
Grasses/No Activity (V4/NO)	2.4	0.5	2.6	0.5	2.6	0.5
Grasses, Trees/No Activity (V4, W1/NO)	1.6	0.3	1.6	0.3	0	0
Grasses/Abandoned Forestry (V4/B2)	1.1	0.2	0.5	0.1	0	0
Shrubs, Grasses/Abandoned Forestry (W2, V4/B2)	0	0	114.8	23.2	2.7	0.5
Grasses, Shrubs/Abandoned Forestry (V4, W2/B2)	0	0	125.9	25.5	1.5	0.3
Shrubs, Trees/Abandoned Forestry (W2, W1/B2)	0	0	90.6	18.3	0	0
Shrubs/Abandoned Forestry (W2/B2)	0	0	12.6	2.6	0	0
Total Area	494.3 ha	100%	494.3 ha	100%	494.3 ha	100%

mature forest and only a 1.1 ha area had any solid evidence of recent cutting. No roads or well developed trails are visible on the air photography for this period.

1950 - Significant changes occurred on 74% of the watershed between 1927 and 1950. Six intermittent trails had been cut through the watershed with extensive logging along three of them. This resulted in a reduction of mature cover to 22.0% of the area and immature cover to 6.3%, while abandoned forestry lands increased to 69.7%. The only areas unaffected by forestry were a small section of the northwest shoreline of the lake, a low-lying damp area to the south of the lake, and a steep inaccessible section of forest to the northeast of the lake. All of the logged area was intensively cut and only isolated stands of trees remained. The watershed in 1950 was riddled with logging trails and drag-line scars, and major access trails are mappable. No active forestry sites were located within the study area. A number of well-maintained roads had been established along rivers and valleys nearby, but they do not appear to have been related to any further development.

1974 - The air photography shows a watershed that from 1950-1974 had undergone regeneration of much of its natural vegetation cover, with 92.3% of the study area covered by maturing forest in 1974. Some 4.8% had immature forest and shrub, and less than 1% showed recent signs of logging activity. A major road had been developed from the nearby Montmorency River Valley to the northwest shore of the lake. Many of the intermittent tracks and logging trails lay abandoned. Nearby Lac Riché became the site of construction and a large building housed the Laval University Forest Research Station. It appears that much of this region was in the same state of regeneration as the Lac Laflamme watershed. Other than the reconstruction of the highway in the Montmorency River Valley and the development of the forestry

station, no obvious man-related activities were evident in 1974. However, 73% of the watershed changed classification from 1950-74 indicating an ecosystem undergoing significant change.

4.4.4 Regional Representativity

Physiographically the watershed is typical of the Laurentian Highland area with its rugged, steep topography and higher elevations. The bedrock is much the same as in the regional setting description with one exception: less acidic gabbros are present in the areas around Lac Laflamme but none are located within the watershed (J. Pkalgraph, personal communication).

The surficial geology and soils of the watershed closely resemble that of the general region. The forest vegetation does not closely match the regional description but the percentage area of Balsam Fir, White Spruce and Birch match regional descriptions of areas that have been heavily logged.

Another major anomaly, from an aquatic standpoint, is groundwater. The Lac Laflamme watershed was chosen partly because of its isolated headwater status which made mass balance nutrient flows relatively easy to perform. However, it has been observed that there is a high amount of groundwater seepage into the lake as the result of an underground spring. This anomaly has been studied extensively and research has done much to improve the understanding of groundwater flows in the watershed. It remains unclear as to what effect this will have on acid precipitation studies and aquatic monitoring in general at Lac Laflamme. Nonetheless, it can be said that the watershed is generally typical of the Laurentian Highland.

4.5 Kejimkujik Study Areas, Nova Scotia

4.5.1 Regional Setting

The Kejimkujik study areas includes seven major rivers and brooks located in three separate study areas in or near Kejimkujik National Park, Nova Scotia. The region is geologically part of the Southern Upland consisting of granite and folded beds of slate and quartzite. Surficial deposits are coarse textured, stony and often shallow except in those places where extensive drumlin fields exist.

Most of the soils have developed from moraine. In general, moderately fine textured soils have developed on moraine derived from Carboniferous shales and mudstones, while moraine derived from slate has medium textured soils. Where these soils are not stony, they are usually suitable for cropland. However, the bulk of the soils in the region have developed on granite and quartzite bedrock and are coarse textured, stony, shallow, and unsuitable for agriculture. Where well-drained developed soils exist, they tend to be Ferro-Humic Podzols and, on the wetter sites, Humic Podzols. The very poorly drained areas have Gleysols mixed with pockets of organic soils. High acidity and low natural fertility are common in most of the region's soils. Numerous small areas of organic soils occur on lowlands and usually consist of water-saturated Sphagnum peat.

The regional topography is gently undulating with elevations up to 244 m a.s.l. Cleared areas on the Southern Upland are isolated to locations where the moraine is fairly deep and not too adverse for agriculture. Approximately 60-65% of the land supports productive forest, the remainder being agriculture land, peatland, burns and exposed rock.

Coniferous forests dominate the landscape, with 37% of the area consisting of Balsam Fir, Red Spruce, White Spruce and Hemlock. Hardwood stands and mixed forests occupy the rest. Where

agricultural abandonment has occurred, White Spruce and Balsam Fir have regenerated. Wet areas support stands of Black Spruce, Tamarack and Red Maple.

The area receives 1 400 mm of precipitation annually and has a mean annual temperature of 6.5°C. The 1980 annual wet sulphate loading was 17 kg/ha/yr. The region is rated as having a low potential to reduce the acidity of atmospheric depositions (Memorandum of Intent 1983).

The Canada Land Inventory has classed most of the soils of the Southern Upland as class 7 for agricultural capability, with thin soils and stoniness being the major limiting factors. The main types of farming in the region are poultry, dairy and fruit production (Hilchey et al. 1968).

4.5.2 Establishment of Study Areas

Two of the Kejimkujik study areas have been the focus of research for quite some time. The West River and Pebbleloggitch Lake areas were incorporated into the new Kejimkujik National Park in 1964. As a result, a number of survey studies were carried out by Parks Canada to inventory the biophysical nature of the park (Stanley et al. 1973). In 1971 field work was completed which would form the basis of a major biophysical land survey report (Gimbarzevsky 1975) prepared by the Canadian Forestry Service for Parks Canada.

In 1978, water sampling on tributaries of rivers in the park area and a research program were initiated by the Canadian Wildlife Service. The sampling was originally undertaken to provide a better understanding of the ecology of the Park. Research included analysis of chemical changes in water, and comparison of lakes for acidity, light penetration and response to light penetration.

During the course of this research, it was discovered that a number of lakes lacked buffering capacity for acid precipitation. LRTAP

research began in earnest in 1979 with the participation of Fisheries and Oceans Canada, the Canadian Forestry Service, and the Canadian Wildlife Service, Inland Waters Directorate, and Atmospheric Environment Service of Environment Canada. Much of this reseach has been summarized by Kerekes and Freedman (1985).

Many of the criteria desired for proper establishment of the calibrated areas already existed in the Park. These criteria included:

1) Accessibility - an established network of old logging roads and ranger roads provides access to those lakes and rivers identified for intensive research.
2) Restricted Use - land within the Park already had protection from certain types of recreational activities and logging.
3) Control of Land Tenure - the Park allows for management of natural resources and further control of development.
4) Undisturbed Environment - this was desired for research. The Park offered an environment largely untouched by recent fires and logging activities.
5) Selection of Lakes - a wide selection of lakes and bogs exist in the Park.
6) Historical Documentation - data existed for much of the Park beginning with inventory studies from the 1960's and a water gauging history of Kejimkujik Lake.

Other factors favoring acid precipitation research in the Park included the high regional sensitivity of lakes to acid precipitation. In addition, two of the watersheds in the Park offered the unique opportunity to monitor a lake free from organic acids (Beaverskin Lake) and an organic lake (Pebbleloggitch Lake) under the same micro- and macro-atmospheric conditions.

Another interesting element for research was the effect of the maritime climate on acid precipitation. Snow cover is not necessarily continuous throughout the winter and the classical

spring melt and episodic "acid shocks" recorded elsewhere seldom occur in this area. Therefore, acid deposition into the lakes tends to be of a more constant nature than in other regions of Canada (J. Kerekes, personal communication). However, there are autumn-period pulses of acidity, unlike other regions, as a result of releases of acidity from the prominent organic wetlands.

At present, the Inland Waters Directorate of Environment Canada is performing regular water monitoring within the Park. The Canadian Wildlife Service is studying sediments and completing supplementary water monitoring. Other studies in the Park have been carried out by the Canadian Forestry Service and various universities. Fisheries and Oceans Canada and the Inland Waters Directorate of Environment Canada, however, have also shifted the focus of their studies out of the Park to the nearby Moose Pit Brook.

Park regulations made watershed gauging difficult. Water manipulations to calculate mass balances, exact flows and deposition were contrary to national park policy. Beaver damming affected mass flow measurements but park rules prohibited the removal by trapping of these beaver. While the Park is logically sound for research, as it restricts accessibility of unwanted development that would alter monitoring results, park policy was found to hamper some aspects of data collection by requiring major environmental impact statements and assessments (K. Fisher, personal communication).

Hence, Fisheries and Oceans Canada and the Inland Waters Directorate of Environment Canada chose to jointly conduct additional research outside the park boundaries at the nearby Moose Pit Brook. Priorities in establishing research at this site included:

1) unrestricted ability to gauge the watershed,
2) existing historical data on the entire Westfield River System (of which Moose Pit Brook is a headwater stream),
3) historical data on Moose Pit Brook fish populations, and
4) easy site accessibility.

Further terrestrial and aquatic research in this watershed was initiated in 1986, with specific evaluation of terrestrial components including peatlands (I. Kessel-Taylor, personal communication).

4.5.3 Watershed Descriptions and Land Use Histories

For the purposes of this report three separate areas have been surveyed for land use change.

(a) Moose Pit Brook is a small watershed area encompassing 2 851 ha located approximately 10 kilometres northeast of Kejimkujik National Park at lat. 44°29'N., long. 65°02'W. Two thirds of the study area is located within Annapolis Municipality, Annapolis County and the other third within Queen's Municipality, Queen's County. The area is roughly bounded on the west and north by South Mud Lake, to the east by Round Lake, and to the south by Tupper and Dean lakes. The area is roughly 152 m a.s.l. and the topography is gently undulating.

(b) Pebbleloggitch Lake, the second study area, is centred on lat. 45°18'N., long. 65°20'W the area encompasses 2 998 ha. It is at an elevation of between 106-122 m a.s.l. and is typified by a gently undulating topography. It contains five lakes (Peskowesk, Peskawa, Beaverskin, Pebbleloggitch and Irving), the Shelburne River, and Beaverskin Brook. The area is roughly bounded to the north by the north shore of Peskowesk Lake, to the east by Big Island, to the south by Irving Lake, and to the west by Granite Lake.

(c) The West River study area is centred at lat. 44°24'N., long. 65°20'W. Most of this area is within Annapolis Municipality, Annapolis County. The area encompasses 10 532.5 ha with elevations between 121-168 m a.s.l. on rolling topography. It contains two rivers (Little and West), six major brooks (Heber Meadow, Innes, Atkins Meadow, Little Liberty, Luxton, and Mount

Tom), seven lakes (Kejimkujik, Mount Tom, High, Luxton, Frozen Ocean, Dennis Boot, and Channel), and numerous bogs and swamps. It is roughly bounded to the east by High Lake, to the south by Big Red Lake, to the west by Dennis Boot Lake, and to the north by Frozen Ocean Lake.

The three Kejimkujik study areas are in the Southern Upland area of Nova Scotia. Bedrock consists of igneous and metamorphic rock, mainly granite, slate, schist and quartzite. The West River study area has three major types of bedrock. The north and east shores of Kejimkujik Lake are composed of metamorphosed greywacke containing quartzite and micaceous slates. A wide band of slate interbedded by quartzite trends from the West River to Frozen Ocean Lake. The western boundary of the study area is underlain by massive fine-to-coarse grained Devonian granite. The Pebbleloggitch area has slate and quartzite on the south shore of Peskowesk Lake and the southeast side of Peskawa Lake while granite dominates the west half of the study area.

Much of the area is covered with morainal and outwash plains, eskers, kames and drumlins. Drumlins and moraines surrounded by compacted deposits are located on the south shores of Peskawa and Peskowesk lakes and the southeast shore of Kejimkujik Lake. Outwash deltas, kames and eskers are found along the north shore of the West River.

Overlying the moraine around Kejimkujik Lake are well-drained, stony sandy loams. These are generally low in nutrients but support Maple, Oak, Birch and Beech hardwood stands, occasionally mixed with White Spruce and Hemlock. West and northwest of Kejimkujik Lake is a rolling, moderately coarse textured morainal plain mixed with sand and gravel. Organic soils are common in poorly drained depressions. Surface materials are mainly sandy loams, loamy sands and gravels, and are very stony. The vegetation in this area consists of Pine, Fir, White Spruce, Hemlock, Sugar Maple, Oak and Yellow Birch. Organic deposits tend to support marsh vegetation and the occasional

Tamarack or Black Spruce. These are often associated with former lakes and ponds that have been infilled with mosses and sedges (Gimbarzevsky 1975).

The Pebbleloggitch Lake area contains well drained, frequently shallow, sandy loams and isolated, poorly drained organic soils in low-lying areas. White Spruce, Balsam Fir, White Pine and Hemlock occasionally combined with Sugar Maple, Oak and Tamarack are the main tree species.

The Moose Pit Brook study area has large bogs in its upper reaches. Trees cover approximately 40% of the ground around the bogs and tend to be of mixed species composition. Mature mixed and softwood species dominate the better drained soils in the central section of the catchment, while on the lower reaches, softwoods interspaced with small areas of hardwood dominate.

It appears that fire has played a major role in influencing vegetation in the three study areas. Specific burn sites identified in field studies are located south of Frozen Ocean Lake, in Atkins Meadow, the north shore of Dennis Boot Lake, Little Liberty Brook, Liberty Bog, Luxton Lake, and on the north shore of Big Red Lake (Gimbarzevsky 1975). Although no major fires have occurred since 1928, few of the trees are older than 81 years and most are between 31-60 years old. The tree species that have suffered most from fire are Sugar Maple, Yellow Birch and White Ash.

Logging has also been a factor within the three Kejimkujik study areas. During the 1800's much of the region was selectively logged of White Pine and Red Oak. The demand for trees for pulp and paper production in the early 1900's and on into the 1950's also resulted in extensive harvesting. At present, the entire area within Kejimkujik National Park is protected from forestry activities. Moose Pit Brook, however, is largely of private land tenure. While ongoing subsistence logging by local landowners is the main land use activity in the area, logging has rarely come to within 180 m of

Moose Pit Brook. Field work in 1986 has indicated that major forestry harvesting goes up to the stream's shoreline on about 60% of the watershed (I. Kessel-Taylor, personal communication).

Only small areas have been influenced by agriculture. This is due mainly to the restrictions placed on agriculture by the poor growing conditions. The Moose Pit Brook study area is the only area that shows evidence of active and abandoned agriculture. Most of the abandoned farmland has reverted to pure stands of White Pine. Pasture land most often has developed into White Birch and Eastern Hemlock in the Park (Gimbarzevsky 1975).

The overall Kejimkujik area has been the site of organized recreational activities since 1906. However, recreation had little impact until the establishment of Kejimkujik National Park in 1964, which permitted recreational land use to reach major proportions. Yet, the net effect within the two watersheds in the Park (Pebbleloggitch and West River) has been one of ecological preservation.

(a) Moose Pit Brook Land Use History

Of the three study areas in the Kejimkujik area, Moose Pit Brook (Figure 9) is the one most influenced by man's activities. Air photographs for 1928, 1955 and 1972 provide the data summarized in Table 12. Land use changes from 1928-55 and 1955-72 are documented in Tables B13 and B14 in Appendix B.

1928 - The 1928 air photos show a landscape that had been extensively logged. Much of the central, northeast and southwest parts of the Moose Pit Brook study area by 1928 had regenerated to immature and mature forest cover interspaced with unregenerated shrub and grass cover. A small area of agriculture had been established on the west boundary. To the north of the

Figure 9: Aerial view of recent logging influence on land cover in Moose Pit Brook, Nova Scotia

TABLE 12

MOOSE PIT BROOK, NOVA SCOTIA, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1928 Coverage		1955 Coverage		1972 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/Abandoned Forestry (W2, W1/B2)	1 605.8	56.3	1 580.0	55.4	337.4	11.8
Shrubs, Grasses/Abandoned Forestry (W2, V4/B2)	274.6	9.6	244.9	8.6	287.0	10.1
Grasses, Shrubs/Abandoned Forestry (V4, W2/B2)	168.1	5.9	161.9	5.7	101.8	3.6
Trees, Grasses/Active Forest (W1, V4/F1)	118.1	4.1	2.7	0.1	2.7	0.1
Trees, Shrubs/Abandoned Forestry (W1, W2/B2)	112.7	4.0	102.7	3.6	1.8	0.1
Water (ZO)	94.1	3.3	90.9	3.2	112.9	4.0
Shrubs, Trees/No Activity (W2, W1/NO)	86.9	3.0	117.1	4.1	1 586.8	55.6
Trees, Shrubs/Active Forestry (W1, W2/F1)	85.1	3.0	0.5	-	0.5	-
Grasses, Shrubs/No Activity (V4, W2/NO)	67.3	2.4	50.8	1.8	37.6	1.3
Shrubs, Trees/Active Forestry (W2, W1/F1)	62.3	2.2	24.2	0.9	0	0
Grasses/Abandoned Forestry (V4/B2)	49.7	1.7	15.9	0.6	2.3	0.1
Shrubs/No Activity (W2/NO)	28.6	1.0	124.8	4.4	266.9	9.4
Shrubs/Abandoned Forestry (W2/B2)	20.1	0.7	192.2	6.7	9.3	0.3
Grassland/Grazing (V3/A1)	18.6	0.6	22.6	0.8	2.1	0.1
Grasses/No Activity (V4/NO)	14.6	0.5	15.7	0.6	15.4	0.5
Shrubs, Grasses/No Activity (W2, V4/NO)	14.0	0.5	0	0	15.6	0.5
Grasses, Shrubs/Active Forestry (V4, W2/F1)	7.3	0.3	20.4	0.7	0	0
Grasses/Forage (V4/A1)	6.6	0.2	3.6	0.1	2.9	0.1
Crops/Tillage (V2/A1)	5.4	0.2	10.0	0.3	10.2	0.4
Trees, Shrubs/No Activity (W1, W2/NO)	2.7	0.1	24.1	0.8	38.0	1.3
Trees, Grasses/No Activity (W1, V4/NO)	2.5	0.1	1.1	-	1.1	-
Shrubs, Grasses/Active Forestry (W2, V4/F1)	1.8	0.8	23.5	0.8	0	0
Grasses, Built-Up/Berry Crops (V4, YO/A1, A2)	1.3	-	1.5	0.1	0.2	-
Grasses, Trees/Berry Crops (V4, W1/A2)	1.3	-	0	0	0	0
Grasses/Storage (V4/M1)	1.0	-	0.6	-	0	0
Grasses, Built-Up/Farm (V4, YO/A4)	0.6	-	0	0	0	0
Barren, Built-Up/Abandoned Forestry (XO, YO/B2)	0.3	-	0	0	0	0
Grasses, Built-Up/Abandoned Forestry (V4, XO/B2)	0.1	-	0.1	-	0	0
Shrubs, Grasses/Abandoned Agriculture (W2, V4/B1)	0	0	4.2	0.1	0	0
Grasses/Active Forestry (V4/F1)	0	0	9.2	0.3	0	0
Water/Wood Storage (ZO/M1)	0	0	3.6	0.1	0	0
Grasses, Shrubs/Abandoned Agriculture (V4, W2/B1)	0	0	0.1	-	0	0
Grasses/Abandoned Agriculture (V4/B1)	0	0	1.2	0.1	0	0
Grassland, Built-Up/Grazing (V3, YO/A1)	0	0	0.2	-	0.2	-
Shrubs/Abandoned Agriculture (W2/B1)	0	0	0.8	-	0	0
Shrubs, Trees/Abandoned Agriculture (W2, W1/B1)	0	0	0.4	-	0	0
Grasses, Shrubs/Grazing (V4, W2/A1)	0	0	0	0	15.0	0.5
Barren/Abandoned Forestry (XO/B2)	0	0	0	0	3.6	0.1
Barren/No Activity (XO/NO)	0	0	0	0	0.3	-
Total Area	2 851.5 ha	100%	2 851.5 ha	100%	2 851.5 ha	100%

agricultural area was a large forest that was being actively logged. Two well-maintained logging roads lead to this region and the landscape was riddled with small logging trails, draglines and abandoned tracks. Only the largest access trails have been mapped.

Of the total land area, 9.6% was being actively logged. One small site was being used for log storage. Abandoned forestry covered 78.2%, and of this 23.0% was recently abandoned with grass and shrub cover. Some 72% of the abandoned forest lands had regenerated to immature tree stands and only 0.1% had reverted to a mature cover. There are no visible signs of forest burns in the Moose Pit Brook study area in 1928.

Mature stands of forest lacking evidence of past logging accounted for only 0.2% of the area. Immature/mature forest mixes totalled to 3.3%; while shrub, grass and sedge cover (including obvious wetlands) encompassed 4.4% of the area. Active agriculture was a minor land activity accounting for only 33.4 ha (1.2%).

1955 - From 1928-55, 1 430.2 ha of land changed classification (50% of the watershed). The bulk of these changes occurred in the abandoned forestry sector. Many of the lands mapped as abandoned forestry in 1928 had regenerated by 1955 and had been logged again and reabandoned. Active forestry lands had decreased to 2.8% of the study area. Abandoned forestry land had increased only slightly to 80.7%; of this, 29% had been recently abandoned with shrub, grass and sedge cover, 67% had regenerated to an immature state and 4% was mature forest.

Mature forest with no perceived activity totalled 0.9% of the area while immature forest covered 4.1%, and

shrub, grass and sedge covers (including damp depressions) accounted for 6.7%. Active agricultural land had increased slightly to 37.8 ha (1.3%). Abandoned farmland accounted for only 2.4 ha. Approximately 3.6 ha of water in Dean Lake was being used for log storage. Hundreds of metres of the nearby Medway River were also intermittently covered by an extensive log boom system which, in some reaches, totally obscured the water surface.

The entire road network appears to have been upgraded from 1928-55 to include roads along the entire length of Moose Pit Brook and a network immediately west of the Brook. Increased forestry activity and site storage on the land between Tupper and Dean Lakes is reflected in the increase in small logging roads in this period. Elsewhere in the study area, many logging roads had been abandoned. Concentrated abandonment existed along Moose Pit Brook, and the northwest, central and southern regions of the study area.

1972 - From 1955-1972, 2 122.4 ha of land (74% of the watershed) in the watershed changed classification. The dominant land cover change between 1955 and 1972 was due to regeneration of abandoned forestry lands. Logging activities declined to 3.1 ha (0.6%) of the area. Abandoned forest declined from 80.7% to 26.1%, of which about 54% had been logged recently and was covered by shrubs, grass and barren surface. Another 45% of abandoned forest had regenerated to a mix of immature/ mature cover.

Mature forests with no perceived activity increased slightly to 1.4% of the watershed. A major proportion of the land use changes up to 1972 is reflected in the increase of mixed immature/mature forest

classifications - from 4.1% in 1955 to 55.6% in 1972. No perceived activity on grass, sedge and shrub areas also increased from 6.7% to 11.7%. Agricultural land remained relatively stable at 1.1% of the total watershed area.

A new road can be noted around the north end of Tupper Lake in the 1972 coverage. As well, a previously abandoned road on the west shoreline has been reconstructed. However, in general, many of the logging trails throughout the area had been abandoned. Only a few intermittent trails to the west were established between 1955 and 1972 and these lead mainly to areas of logging. Other changes include an increase in the water level on Dean Lake reflected in an alteration of the north shoreline configuration, and the removal of log booms and lumber storage in Dean Lake and the nearby Medway River.

(b) Pebbleloggitch Lake Study Area Land Use History

Land cover and activity for each period, 1928, 1955 and 1971 are summarized in Table 13 Land use changes from 1928-1955 and 1955-1971 are documented in Tables B15 and B16 in Appendix B.

1928 - The Pebbleloggitch Lake study area (Figure 10) had been widely influenced by logging practices in the previous two centuries as indicated by historical documents. The 1928 air photographs show abandoned logging trails in the southeast section of the study area. However, regeneration of the forest was largely complete and delineation of the abandoned land is impossible.

Mature forest growth occupied 15.1% of the study area. A mix of immature/mature growth encompassed 40.2% and shrub, grass and sedges (including damp depressions)

Figure 10: Pebbleloggitch Lake Study Area

TABLE 13

PEBBLELOGGITCH LAKE AREA, NOVA SCOTIA, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1928 Coverage		1955 Coverage		1971 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1/N0)	1 203.9	40.2	704.6	23.5	536.8	17.9
Water (Z0)	779.0	26.0	775.1	25.9	778.8	26.0
Trees, Shrubs/No Activity (W1, W2/N0)	433.5	14.5	179.3	6.0	40.7	1.4
Grasses/No Activity (V4/N0)	254.9	8.5	250.6	8.4	249.9	8.3
Shrubs, Grasses/No Activity (W2, V4/N0)	215.8	7.2	180.3	6.0	170.8	5.7
Shrubs/No Activity (W2/N0)	49.7	1.7	14.7	0.5	14.8	0.5
Grasses, Shrubs/No Activity (V4, W2/N0)	42.9	1.4	50.6	1.7	48.8	1.6
Trees/No Activity (W1/N0)	18.0	0.6	17.5	0.6	17.5	0.6
Grasses, Trees/No Activity (V4, W1/N0)	0.8	-	2.3	0.1	2.3	0.1
Barren, Grasses/No Activity (X0, V4/N0)	0.1	-	0.1	-	0.2	-
Grasses, Shrubs/Active Forestry (V4, W2/F1)	0	0	443.9	14.8	0	0
Shrubs, Grasses/Active Forestry (W2, V4/F1)	0	0	235.2	7.8	1.0	-
Grasses/Active Forestry (V4/F1)	0	0	80.9	2.7	0	0
Grasses, Trees/Active Forestry (V4, W1/F1)	0	0	29.0	1.0	0	0
Trees, Grasses/Active Forestry (W1, V4/F1)	0	0	23.8	0.8	0	0
Water/Wood Storage (Z0/M1)	0	0	3.9	0.1	0	0
Barren, Grasses/Forestry Site (X0, V4/F2)	0	0	3.0	0.1	0	0
Shrubs/Active Forestry (W2/F1)	0	0	2.6	0.1	0	0
Barren/Forestry Site (X0/F2)	0	0	0.5	-	0	0
Grasses, Barren/Active Forestry (V4, X0/F1)	0	0	0.5	-	0	0
Built-Up/Transportation (Y0/H0)	0	0	0.2	-	0	0
Barren/Abandoned Forestry (X0/B2)	0	0	0	0	0.7	-
Shrubs, Trees/Abandoned Forestry (W2, W1/B2)	0	0	0	0	517.8	17.3
Barren, Grasses/Abandoned Forestry (X0, V4/B2)	0	0	0	0	0.2	-
Built-Up, Grasses/Abandoned Forestry (Y0, V4/B2)	0	0	0	0	0.4	-
Grasses/Abandoned Forestry (V4/B2)	0	0	0	0	1.9	0.1
Grasses, Shrubs/Abandoned Forestry (V4, W2/B2)	0	0	0	0	0.6	
Trees/Abandoned Forestry (W1/B2)	0	0	0	0	0.9	-
Trees, Shrubs/Abandoned Agriculture (W1, W2/B1)	0	0	0	0	2.9	0.1
Grasses, Barren/Abandoned Forestry (V4, X0/B2)	0	0	0	0	1.5	0.1
Shrubs, Grasses/Abandoned Forestry (W2, V4/B2)	0	0	0	0	609.3	20.3
Shrubs/Abandoned Forestry (W2/B2)	0	0	0	0	0.8	-
Total Area	2 998.6 ha	100%	2 998.6 ha	100%	2 998.6 ha	100%

covered 18.8%. No recent road construction or any other development is visible in the photography for 1928.

1955 - By 1955, extensive forestry around the lakes and in the southeast portion of this area had occurred. Well-maintained logging roads encircled the lakes and many small tracks and access roads lead to the forested areas away from the shorelines. In all, 890.4 ha (31% of this study area) changed classification from 1928-1955.

Active forestry accounted for 27.3% of the land area. Three large log booms occupied 3.9 ha of the water surface on Beaverskin Lake. A small road had been built on fill over a short causeway to a peninsula in the lake to facilitate logging.

Mature forests with no perceived activity had decreased to 6.7%; mixed mature/immature forest cover had fallen to 23.5%; and shrub, grass and sedges edged up to 20.9%. Forests had matured significantly in the southwest portion of the study area where no visible evidence of forestry remained; this tends to support historical documentation on logging.

1971 - Logging in the Pebbleloggitch Lake area was almost completely abandoned during the 1955-1971 time period. Abandoned logging trails around the lakes and in the southeast show the extent of forestry in the area. Less intense forestry activities had occurred west of Granite Lake Falls. A total of 1 145.6 ha (38% of the area) changed classification in this period. The dominant change was from active forestry to abandoned forestry. Active forestry was confined to less than one hectare in the southeast outside the Park.

Recently abandoned forestry encompassed 20.5% of the area, immature abandoned forestry mixed with mature forest encompassed 17.3%, and mature stands occupied 0.1%.

Mature stands with no perceived activity accounted for 2.0%, while immature/mature mixes equalled 17.9% and shrubs 16.1%. The log booms on Beaverskin lake had been removed by 1971. Although much of the road system was abandoned, a ranger road had taken over the main logging road around the lakes and it was still relatively well-maintained in 1971.

(c) West River Study Area Land Use History

Land cover and activity of the West River study area (Figure 11) for 1928, 1955 and 1971 are summarized in Table 14. Land use changes for the periods of 1928-1955 and 1955-1971 are documented in Tables B17 and B18 in Appendix B.

1928 - The 1928 photography shows the West River study area in Kejimkujik National Park to have been relatively untouched by man's activities prior to 1928 with 2.8% of the study area covered in mature forest, 60.5% encompassed by a mix of immature/mature forest cover, and 27.5% with a combination of shrubs, grass and sedges. Although the photography is of poor quality, the amount of immature/mature forest cover appears to indicate that fire and/or forestry harvesting activities had occurred well in advance of the air photography.

The area south and west of Frozen Ocean Lake had faint evidence of abandoned trails and exhibited very little mature forest growth. Large expanses of land north and east of Little River as well as a number of sites along

Figure 11: Mouth of Atkins Brook at Kejimkujik Lake in West River Study Area

TABLE 14

WEST RIVER STUDY AREA, NOVA SCOTIA, LAND USE HISTORY

LAND COVER/ACTIVITY CLASS	1928 Coverage		1955 Coverage		1971 Coverage	
	ha	(%)	ha	(%)	ha	(%)
Shrubs, Trees/No Activity (W2, W1/N0)	6 304.8	59.9	6 582.4	62.5	5 005.1	47.5
Shrubs, Grasses/No Activity (W2, V4/N0)	1 695.1	16.1	1 436.3	13.6	1 457.9	13.8
Water (Z0)	965.5	9.2	965.8	9.2	965.9	9.2
Grasses, Shrubs/No Activity (V4, W2/N0)	854.4	8.1	547.7	5.2	320.2	3.0
Grasses/No Activity (V4/N0)	331.5	3.1	328.8	3.1	327.5	3.1
Trees, Shrubs/No Activity (W1, W2/N0)	212.2	2.0	275.6	2.6	1 611.7	15.3
Shrubs/No Activity (W2/N0)	65.0	0.6	156.3	1.5	109.5	1.0
Trees/No Activity (W1/N0)	52.0	0.5	54.3	0.5	48.2	0.5
Trees, Grasses/No Activity (W1, V4/N0)	27.9	0.3	27.9	0.3	25.2	0.2
Grasses, Trees/No Activity (V4, W1/N0)	15.6	0.1	13.3	0.1	13.3	0.1
Shrubs, Barren/No Activity (W2, X0/N0)	4.4	-	4.4	-	4.4	-
Sedges, Water/No Activity (V4, Z0/N0)	3.9	-	3.9	-	3.9	-
Barren/No Activity (X0/N0)	0.2	-	0.2	-	0.2	-
Shrubs, Grasses/Abandoned Forestry (W2, V4/B2)	0	0	82.6	0.8	266.0	2.5
Grasses, Shrubs/Abandoned Forestry (V4, W2/B2)	0	0	25.7	0.2	25.7	0.2
Shrubs, Grasses/Active Forestry (W2, V4/F1)	0	0	22.7	0.2	0	0
Grasses, Shrubs/Active Forestry (V4, W2/F1)	0	0	4.6	-	0	0
Shrubs, Trees/Abandoned Forestry (W1, W2/B2)	0	0	0	0	321.2	3.0
Shrubs/Abandoned Forestry (W2/B2)	0	0	0	0	25.0	0.2
Water, Sedges/No Activity (Z0, V4/N0)	0	0	0	0	1.2	-
Built-Up, Barren/Abandoned Forestry (Y0, X0/B2)	0	0	0	0	0.4	-
Total Area	10 532.5 ha	100%	10 532.5 ha	100%	10 532.5 ha	100%

the major brooks also showed little growth. Only one intermittent, abandoned trail was defined enough to map. It ran through a low-lying, wet area south of West River.

1955 - In total, 1 341.4 ha (13% of the study area) changed classification between 1928 and 1955. Mature forest cover increased slightly to 3.4% of the West River study area by 1955. Mixes of immature/mature forest cover also increased to 68.4%, with the majority of this occurring on the fire and/or forestry sites noted in 1928. Shrubs, grasses and sedges decreased slightly to 22.1%.

Evidence of forestry occurring in the 1928-1955 time period is visible in a number of locations. Recently abandoned forestry areas accounted for approximately 1.0% of the area in 1955, while active forestry was found on 27.3 ha (0.2%) of the study area.

Nineteen abandoned forestry trails were evident in the area. Three well-defined intermittent trails existed in the southern half of the watershed and one heavily used track existed on the west edge of Kejimkujik Lake. Other than the evidence of forestry, no other type of man or fire-related activity is noted on the 1955 air photography.

1971 - Between 1955 and 1971, 2 343.9 ha (22% of the West River study area) changed classification. Mature forest growth with no perceived activity increased to 16.0% by 1971. Immature/mature forest mixes decreased to 48.6% while sedge, grass and shrub cover decreased slightly to 20.1%. Recently abandoned forestry increased to 3.0% while older partially regenerated forestry sites also occupied 3.0%. No active forestry is noted on the 1971 photography.

Much of the abandoned forestry is located between Mount Tom Lake and Luxton Lake, as well as on the Indian Point Peninsula in Kejimkujik Lake. A network of abandoned forestry roads and intermittent trails had developed within the forestry areas. Only the major access routes have been mapped for the purposes of this report.

4.5.4 Regional Representativity

When considered separately, the West River, Pebbleloggitch Lake and Moose Pit Brook study areas do not adequately represent the Southern Upland area of Nova Scotia. While each of these areas is typical of environments found within the Upland, they are too specific to present a general sample of regional environments. However, when all three areas are taken as a whole, a wide spectrum of river, brook and lake environments, as well as a good selection of "undisturbed" and regenerating forests ensures that a balanced, representative regional sampling is achieved.

5.0 SUMMARY AND CONCLUSIONS

This report provides a summary, reviewed in Table 15, of land cover and land activity changes in a series of eastern Canada LRTAP calibrated watersheds which are supported by federal and provincial acid precipitation research programs.

The Experimental Lakes Area near Kenora, Ontario has photography available only for 1969. However, a more recent 1975 LANDSAT satellite image analysis of land cover in this area suggests the area is somewhat dynamic in terms of the influence of forest fires with forestry activities occurring along its perimeters. The Turkey Lakes Watershed near Sault Ste. Marie, Ontario is a highly stable ecosystem which experienced virtually no change from 1937-1961 and 1961-1974.

TABLE 15

LRTAP CALIBRATED WATERSHEDS, LAND USE CHANGE SUMMARY

Watersheds	Period of Analysis	Total Area (ha)	Period A Change		Period B Change	
			(ha)	(%)	(ha)	(%)
1. Dorset Basins, Ontario	A: 1935-1969 B: 1969-1981					
1(a) Plastic Lake		193	1	-	0	-
1(b) Dickie, Heney Lakes		1 497	186	12%	35	2%
1(c) Chub Lake		644	82	13%	8	1%
1(d) Blue Chalk, Red Chalk Lakes		1 251	2	-	1	-
1(e) Harp, Jerry Lakes		2 497	459	18%	196	8%
2. Turkey Lakes Watershed, Ontario	A: 1937-1961 B: 1961-1974	1 265	0	-	2	-
3. Experimental Lakes Area, Ontario	A: 1969	17 203	-	-	-	-
4. Lake Laflamme, Quebec	A: 1927-1950 B: 1950-1974	494	367	74%	359	73%
5. Kejimkujik National Park Basins, Nova Scotia	A: 1928-1955 B: 1955-1971					
5(a) Moose Pit Brook		2 852	1 430	50%	2 122	74%
5(b) Pebblebogitch/Beaverskin		2 999	890	31%	1 146	38%
5(c) West River		10 533	1 341	13%	2 344	22%

Land use analysis of the eight Dorset basins indicates that from 1935-1969 significant changes of 12-18% occurred in some basins, but in the more recent 1969-1981 period most of the basins had become highly stable, forested ecosystems. Only minor amounts of cottage and road development on 1-2% of the area are recorded with the exception of the Harp and Jerry Lakes area where an 8% change has occurred.

In Quebec, the Lac Laflamme Watershed underwent extensive logging activity from 1927-50 with land cover changes on 74% of the watershed. After 1974, forestry in this area was abandoned and most of the logged areas regenerated to natural stands of forest and shrub. From 1950-74, 73% of the watershed again changed in classification. This change however represents an ecosystem undergoing natural succession and it appears human activities in the area are no longer a factor in the ongoing changes.

Three separate study areas, near or within Kejimkujik National Park, Nova Scotia have been examined. The Moose Pit Brook appears to be, ecologically, a unstable ecosystem with substantial and continuing human activity and natural changes occurring. The most recent of the two periods studied, 1955-1972, indicates changes to over 74% of the area. The two study areas within the National Park appear more stable. The Pebbleloggitch/Beaverskin Lakes area is an ecosystem subject to continuing natural changes due to forest maturation and fire protection. From 1955-71, some 38% of this area changed in terms of land cover, mainly due to creation of the Park in 1964. The larger West River study area, is also undergoing changes due to natural forest maturation, with 22% recorded as changing from 1955-71.

Based upon the measurement of land use change over the most recent periods available through air photography analysis, the Canadian LRTAP calibrated watersheds may be ranked as follows:

Little Change	- Plastic Lake
	- Dickie/Heney lakes
	- Chub Lake
	- Blue Chalk/Red Chalk lakes
	- Turkey Lakes Watershed
Minor Change	- Harp/Jerry lakes
	- Experimental Lakes Area
	- West River/Pebbleloggitch Lake areas
Major Change	- Lac Laflamme Watershed
	- Moose Pit Brook

Evaluation of the representativity, within their individual regional settings, of all these watersheds suggests most are, individually, a good sampling of otherwise extensively distributed landscapes in their area. In the case of the three study areas in Nova Scotia, representativity appears to be best achieved by considering all three in unison as each is individually representative of limited sectors of their Atlantic landscape.

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APPENDIX A:

LIST OF AERIAL PHOTOGRAPHY USED

TABLE A1

AERIAL PHOTOGRAPHY USED FOR LAND USE CHANGE ANALYSIS

WATERSHED	DATE OF PHOTOGRAPHY	SCALE	PHOTO NUMBERS
1. Dorset, Ontario Study Areas			
* Plastic Lake	May 1935	1:17 410	A4915/67-68
	-- 1969*	1:38 000	A21009/97-100
	May 1981	1:53 000	A25690/62-64
* Dickie/Heney Lakes	May 1935	1:16 716	A4914/1
	-- 1971*	1:38 000	A22319/172-174
	June 1983	1:52 000	A26300/123-125
* Chubb Lake	May 1935	1:16 716	A4917/86-87
	-- 1969*	1:38 000	A21009/96-97
	May 1981	1:53 000	A25690/61-64
* Red Chalk/Blue Chalk Lakes	May 1935	1:16 716	A4916/14-15
	-- 1969*	1:38 000	A21009/97-100
	May 1981	1:53 000	A25690/61-64
* Harp/Jerry Lakes	-- 1935	**	HA406/10-15
	-- 1969*	1:38 000	A21008/104-105
	June 1983	1:52 000	A26300/74
2. Turkey Lakes, Ontario	-- 1937*	1:17 015	A5660/42-47 A5665/79-84
	-- 1961*	**	A13127/95-97
	July 1974	1:50 000	A23752/231-233
3. Experimental Lakes Area, Ontario	Aug. 1969	1:49 200	A21199/8-11 A21200/49-51, 69-72
4. Lac Laflamme, Quebec	Sept. 1927	**	F1200/2638-2640
	-- 1950*	1:40 000	A12961/413
	Oct. 1974	1:40 800	A23725/162
5. Kejimkujik Study Areas Nova Scotia			
* Moose Pit Brook	-- 1928*	**	A1155/7-12 A1156/79-87 A1162/81-90
	-- 1955*	1:16 600	A14660/57-58, 140-143
	-- 1972*	1:36 800	A22993/145-148
* Pebbleloggitch/Beaverskin Lakes	-- 1928*	**	A477/53-60 A478/78-85 A481/39-45
	-- 1955*	1:16 600	A14710/64-67, 114-118
	-- 1971*	1:12 800	A22497/11-15, 248-251, 276-280
* West River	-- 1928*	**	A483/25-35 A484/58-71 A496/29-42 A497/55-66 A1160/45-58 A1635/67-82
	-- 1955*	1:16 600	A14654/154-160 A14709/77-81 A14724/197-203 A14725/23-28, 150-153
	-- 1971*	1:12 800	A22497/71-75, 93-98, 112-118, 139-146, 159-167, 184-192

* Precise date not recorded.
** Scale approximately 1:15 840.

APPENDIX B:

DETAILED LAND USE CHANGE DATA FOR EACH CALIBRATED WATERSHED (TABLES B1-B18)

TABLE B1

CHANGES IN LAND USE, 1961-1974, TURKEY LAKES WATERSHED, ONTARIO*

From 1961	To 1974	Area (ha)	% Loss of 1961 Class
NO/W1**	NO/XO	1.3	0.1
NO/W1	NO/V4	0.3	-
Total change		1.6 ha	1%

* No changes in land cover or activity are recorded for 1937-61.
** Refer to Table 2 in text for legend to classification system in this and all subsequent tables of Appendix B.

TABLE B2

CHANGES IN LAND USE, 1935-1969, PLASTIC LAKE, ONTARIO*

From 1935	To 1969	Area (ha)	% Loss of 1935 Class
NO/W2, V4	NO/W2, W1	0.3	0.3
NO/V4, W2	NO/W2, W1	0.8	26.6
Total Change		1.1	1%

* There are no observed changes for 1969-1981 for the Plastic Lake area.

TABLE B3

CHANGES IN LAND USE, 1935-1971, DICKIE AND HENEY LAKES, ONTARIO

From 1935	To 1971	Area (ha)	% Loss of 1935 Class
NO/W2, W1	R1, DO/W2, YO	43.6	6.0
B2/W2, V4	NO/W2, W1	30.4	98.4
A1/W2, V4	B1/W1, W2	22.9	58.3
NO/W2, W1	NO/W2, V4	19.7	2.7
A1/V3	B1/W2, V4	17.6	53.4
A1/W2, V4	B1/W2, W1	8.5	21.6
NO/W1, W2	NO/W2, V4	6.2	2.5
NO/V4, W2	NO/W2, W1	6.1	95.6
A1/W2, V4	B1/W2, V4	5.7	14.4
A1/V4, W2	B1/W2, W1	5.3	38.0
A1/V4, W2	R1, DO/W2, YO	4.3	31.0
NO/W2, V4	NO/W2, W1	4.1	4.9
A1/V4, W2	B1/W2, V4	3.4	24.6
NO/W2	NO/W2, W1	3.0	51.7
A1/W2, V4	B1/W2, V4	1.9	5.0
NO/W2, W1	NO/W2	0.9	0.1
NO/W2, W1	NO/V4	0.7	0.1
B2/W2, V4	R1, DO/W2, YO	0.5	1.5
NO/W2, W1	A1, DO/V4, YO	0.4	0.1
A1/W2, V4	DO/YO, V4	0.3	0.8
A1, A2/V4, YO	B1/W2, V4	0.2	100.0
Unclassified*	NO/W2, W1	147.6	90.6
Unclassified*	R1, DO/W2, YO	11.2	6.9
Unclassified*	NO/V4, W2	4.6	2.8
Unclassified*	A1, DO/V4, YO	0.6	0.3
Total Change		349.7 ha	23%
* Adjusted total to removed unqualified changes		185.7 ha	12%

TABLE B4

CHANGES IN LAND USE, 1971-1983, DICKIE AND HENEY LAKES, ONTARIO

From 1971	To 1983	Area (ha)	% Loss of 1971 Class
B1/W2, V4	NO/W2, W1	21.3	74.3
NO/W2, W1	R1, DO/W2, YO	7.0	0.8
NO/W2, V4	NO/W2	6.2	5.9
NO/W2, W1	DO/YO, V4	0.4	0.1
Total Change		34.9 ha	2%

TABLE B5

CHANGES IN LAND USE, 1935-1969, CHUB LAKE, ONTARIO

From 1935	To 1969	Area (ha)	% Loss of 1935 Class
B1/W2, V4	NO/W2, W1	32.6	71.3
A1/W2, V4	B1/W2, V4	10.4	89.2
B1/W2, V4	NO/W2, V4	8.4	18.4
NO/W1, V4	NO/W2, V4	5.9	32.2
A1/V4, W2	B1/W2, V4	5.5	100.0
NO/W1, V4	NO/W2, W1	3.7	20.4
A1/V3	B1/W2, V4	2.9	100.0
NO/V4, W2	NO/W2, V4	2.7	79.9
NO/W2, V4	NO/W2, W1	2.4	8.1
B1/W2, V4	B1/W2, W1	2.2	4.9
NO/W2, V4	NO/W2	1.4	4.8
A1/W2, V4	B1/W2, W1	1.2	10.6
A1/V4, YO	B1/W2, V4	1.2	100.0
B1/W2, V4	A1/V3	0.8	1.8
NO/W2, W1	NO/V4, W2	0.5	0.2
A4/V4, YO	B1/W2, V4	0.4	0.1
Total Change		82.2 ha	13%

TABLE B6

CHANGES IN LAND USE, 1969-1981, CHUB LAKE, ONTARIO

From 1969	To 1981	Area (ha)	% Loss of 1969 Class
B1/W2, V4	NO/W2, W1	5.9	26.7
NO/W2, V4	NO/W2	0.9	2.1
A1/V3	B1/W2, V4	0.8	100.0
B1/W2, V4	NO/W2, V4	0.3	1.4
Total Change		7.9 ha	1%

TABLE B7

CHANGES IN LAND USE, 1935-1969, BLUE CHALK AND RED CHALK LAKES, ONTARIO

From 1935	To 1969	Area (ha)	% Loss of 1935 Class
NO/W2, V4	R1, DO/W2, YO	1.7	0.5
Total Change		1.7 ha	1%

TABLE B8

CHANGES IN LAND USE, 1969-1981, BLUE CHALK AND RED CHALK LAKES, ONTARIO

From 1969	To 1981	Area (ha)	% Loss of 1969 Class
NO/W2, W1	R1, DO/W2, YO	0.4	0.1
Total Change		0.4 ha	1%

TABLE B9

CHANGES IN LAND USE, 1935-1969, HARP AND JERRY LAKES, ONTARIO

From 1935	To 1969	Area (ha)	% Loss of 1935 Class
NO/W2, W1	NO/W1, W2	88.7	8.7
A1/V3	B1/W2, V4	37.4	49.3
B2/W2, W1	NO/W2, W1	29.1	100.0
A1/V4, W2	B1/W2, V4	25.2	32.9
NO/W1, W2	R1, DO/W2, YO	20.3	2.5
NO/V4, W2	NO/W2, W1	17.8	40.2
A1/V4, W2	B1/W2, W1	17.0	22.2
NO/V4, W2	NO/W2, V4	16.9	38.3
B1/V4, W2	NO/W2	16.7	65.3
A1/W2, V4	B1/W2, V4	15.1	45.2
A1/W2, V4	B1/W2	13.8	41.3
NO/W2, V4	NO/W2, W1	13.1	12.2
NO/W2, W1	R1, DO/W2, YO	12.7	1.2
NO/W2, V4	NO/W1, W2	11.8	11.0
A1/V4, W2	B1/W2	11.0	14.3
A1/V4	B1/W2	10.6	100.0
ZO	NO/W2, ZO	10.0	6.9
A1/V4, W2	B1/V4, W2	9.5	12.4
B1/V4, W2	NO/W2, V4	8.8	34.4
A1/V3	A1/W2, V4	7.8	10.3
A1/V2	A1/V3	7.6	100.0
NO/W2, V4	NO/W2	6.7	6.2
A1/V3	B1/V4, W2	6.3	8.3
NO/W2	NO/W2, V4	6.3	8.8
NO/W2	NO/W1, W2	4.8	6.7
NO/V4, W2	NO/W1, W2	4.7	10.6
A1/V3	B1/W2, W1	4.4	5.8
NO/W2, V4	NO/W2	3.9	3.7
B1/W2, V4	NO/W2, W1	3.9	100.0
A1/W2, V4	B1/W2, W1	2.9	8.7
A1/V3	R1, DO/W2, YO	2.8	3.7
NO/V4	NO/W2, V4	2.7	29.3
NO/W2	B1/W2, V4	1.6	2.2
NO/W2	NO/W2, W1	1.5	2.1
A1/V4, W2	A1/V3	1.4	1.9
A1/V3	B1/W2	1.2	1.5
A1, A2/V4, YO	B1/W2, V4	0.6	50.5
A1/V3	NO/W2, ZO	0.6	0.8
A1, A2/V4, YO	B1/V4, W2	0.4	28.9
A1, DO/V4, YO	B1/W2, V4	0.4	64.9
NO/W1, W2	NO/W2, V1	0.3	(-)
A1, A2/V4, YO	A1, DO/V4, YO	0.3	20.5
NO/W1, W2	A1/V3	0.2	(-)
A1/V4, YO	B1/W2, V4	0.2	60.8
A1/V4, YO	B1/W2	0.1	39.2
A1, DO/V4, YO	B1/W2	0.1	13.7
NO/YO	NO/W2	0.1	100.0
A4/V4, YO	B1/W2, V4	0.1	100.0
Total Change		459.4 ha	18%

TABLE B10

CHANGES IN LAND USE, 1969-1983, HARP AND JERRY LAKES, ONTARIO

From 1969	To 1983	Area (ha)	% Loss of 1969 Class
B1/W2, V4	NO/W2, W1	36.2	44.9
B1/W2, V4	NO/W2	15.9	19.7
B1/V4, W2	NO/W2, V4	15.4	94.8
NO/W2, W1	B2/V4, W2	13.1	1.3
B1/W2	NO/W2, W1	12.6	35.6
NO/W2, V4	NO/W2	11.9	11.0
B1/W2	NO/W2	11.6	32.7
A1/V4, W2	NO/W2, V4	11.2	90.0
NO/W1, W2	R1, DO/W2, YO	11.1	1.2
NO/W1, W2	B2/W2, V4	10.6	1.2
A1/V3	A1/W2, V4	8.7	35.1
A1/V3	NO/W2	7.7	31.3
A1/V3	B1/W2, W2	7.3	29.6
B1/W2, V4	NO/W2, V4	6.7	8.3
NO/W2, V4	NO/W2, W1	4.5	4.2
NO/W2, W1	R1, DO/W2, YO	3.4	0.3
B1/W2, W1	NO/W2, W1	2.9	11.9
B1/W2, W1	NO/W1, W2	1.5	6.0
B1/W2, V4	R1, DO/W2, YO	0.9	1.1
NO/W2, W1	DO/YO, V4	0.9	0.1
NO/W2, W1	A1/V3	0.6	0.1
A1/V3	B1/W2, V4	0.5	2.1
B1/W2, V4	B2/V4	0.4	0.5
A1, DO/V4, YO	NO/W2, V4	0.1	16.4
Total change		195.7 ha	8%

TABLE B11

CHANGES IN LAND USE, 1927-1950, LAC LAFLAMME, QUEBEC

From 1927	To 1950	Area (ha)	% Loss of 1927 Class
NO/W2, W1	B2/W2, V4	103.7	26.7
NO/W2, W1	B2/V4, W2	97.2	25.1
NO/W2, W1	B2/W2, W1	86.5	22.3
NO/W2	B2/V4, W2	28.3	39.2
NO/W2	B2/W2, V4	11.0	15.2
NO/V4, W2	NO/W2, W1	7.5	93.5
NO/W2	B2/W2	7.3	10.1
NO/W2, W1	NO/W2	7.0	1.8
NO/W2, V4	NO/W2, W1	4.2	56.1
NO/W2	B2/W2, W1	3.1	4.2
NO/W2	NO/W2, W1	3.0	4.2
NO/W2, W1	B2/W2	2.9	0.8
NO/W2, V4	B2/W2	2.4	31.5
B2/V4	B2/W2, W1	1.1	100.0
NO/V4, W2	NO/W2	0.5	6.5
NO/W2	B2/V4	0.4	0.5
NO/W2, V4	B2/V4, W2	0.4	5.1
NO/W2, V4	NO/V4	0.2	3.3
NO/W2, W1	B2/V4	0.1	-
NO/V4	B2/W2, V4	0.1	4.5
NO/W2, V4	B2/W2, W1	0.1	0.6
Total Change		367.0 ha	74%

TABLE B12

CHANGES IN LAND USE, 1950-1974, LAC LAFLAMME, QUEBEC

From 1950	To 1974	Area (ha)	% Loss of 1950 Class
B2/V4, W2	NO/W2, W1	118.0	93.8
B2/W2, V4	NO/W2, W1	111.0	96.7
B2/W2, W1	NO/W2, W1	90.6	100.0
NO/W2	NO/W2, W1	13.5	50.5
B2/W2	NO/W2, W1	12.6	100.0
B2/V4, W2	NO/W2, V4	2.8	2.2
B2/V4, W2	B2/W2, V4	2.6	2.0
B2/W2, V4	NO/W2, V4	1.7	1.5
NO/V4, W1	NO/W2, W1	1.6	100.0
B2/W2, V4	NO/W2	1.5	1.3
NO/W2	NO/W2, V4	1.1	4.2
B2/V4, W2	NO/W2	1.0	0.8
B2/V4	NO/W2	0.5	100.0
NO/W2, W1	NO/W2, V4	0.1	0.1
Total Change		358.6 ha	73%

TABLE B13

CHANGES IN LAND USE, 1928-1955, MOOSE PIT BROOK, NOVA SCOTIA

From 1928	To 1955	Area (ha)	% Loss of 1928 Class
B2/W2, W1	B2/W2, V4	125.6	7.8
B2/W2, W1	B2/W2	118.0	7.4
F1/W1, V4	B2/W2, W1	106.9	90.6
B2/V4, W2	B2/W2, W1	86.7	51.5
B2/W2, V4	B2/W2, W1	77.5	28.2
B2/W2, W1	B2/V4, W2	69.8	4.3
B2/W2, V4	NO/W2	69.3	25.2
F1/W1, W2	B2/W2, W1	62.0	72.8
B2/W2, V4	NO/W2, W1	49.3	18.0
B2/W2, W1	NO/W2, W1	39.5	2.5
F1/W2, W1	B2/W2, W1	38.6	62.0
B2/W2, W1	NO/W2	37.1	2.3
B2/W2, W1	B2/W1, W2	34.5	2.1
NO/W2, W1	B2/W2, V4	30.8	35.5
B2/W1, W2	B2/W2, V4	30.6	27.1
NO/W2, W1	B2/W2, W1	28.0	32.2
B2/W1, W2	B2/W2, W1	25.5	22.6
F1/W2, W1	B2/W2, V4	24.1	38.6
B2/V4	B2/V4, W2	23.8	47.9
B2/W2, W1	F1/W2, W1	20.5	1.3
NO/W2	B2/W2, W1	17.8	62.5
B2/V4, W2	B2/W2	17.3	10.3
B2/W2, V4	B2/W2	16.8	6.2
B2/W2, W1	F1/W2, V4	15.7	1.0
B2/W2, V4	B2/V4, W2	14.8	5.4
B2/W2, W1	B2/W1, W2	14.6	0.9
B2/W2, W1	NO/W1, W2	13.7	0.9
B2/W2, V4	F1/V4, W2	13.4	4.9
NO/W2	B2/W2	12.5	43.8
F1/W1, W2	B2/W2, V4	12.3	14.4
NO/V4, W2	B2/W2, W1	11.9	17.7
B2/W2	NO/W2	10.0	49.7
B2/V4	B2/W2	9.9	20.0
B2/W1, W2	B2/W2	9.4	8.4
B2/W2, W1	F1/V4, W2	7.1	0.4
F1/W1, W2	NO/W2	6.6	7.8
B2/V4, W2	NO/W1, W2	6.3	3.8
B2/V4	B2/W2, W1	6.3	12.5
B2/W2, W1	B2/V4	6.2	0.4
NO/W2, V4	B2/W2, W1	6.2	44.0
F1/V4, W2	B2/W2, W1	5.7	78.4
NO/W2, V4	A1/V3	5.2	37.2
B2/W2	B2/W2, W1	5.1	25.2
B2/V4, W2	NO/W2	4.7	2.8
B2/W1, W2	F1/W2, V4	4.7	4.1
B2/W2, V4	B2/W1, W2	4.5	1.6
B2/W2, W1	F1/V4	4.4	0.3
F1/W1, V4	B2/W2	4.3	3.7
B2/W2, V4	F1/V4	4.3	1.6
F1/W1, V4	B2/V4, W2	4.0	3.4
A1/V4	B1/W2, V4	3.9	58.9
B2/W2, V4	NO/V4	3.8	1.4
ZO	M1/ZO	3.2	3.4
A1/V3	A1/V2	3.1	17.2

TABLE B13 (cont'd)

From 1928	To 1955	Area (ha)	% Loss of 1928 Class
B2/W2	B2/W2, V4	2.9	14.5
B2/W2, V4	F1/W2, V4	2.9	1.1
NO/V4, W2	B2/W1, W2	2.6	3.8
NO/V4	A1/V3	2.2	14.8
NO/W2, V4	B2/W2, W1	2.1	14.6
B2/V4, W2	F1/W2, W1	2.1	1.2
F1/W1, W2	B2/W1, W2	2.0	2.4
F1/W2, V4	B2/W2, W1	1.8	100.0
F1/V4, W2	F1/W2, W1	1.6	21.6
NO/W1, V4	NO/W1, W2	1.4	55.6
A1/V4	B1/V4	1.2	18.6
B2/V4	B2/W1, W2	1.2	2.4
NO/V4	NO/W2, W1	1.0	6.7
M1/V4	A1/V4	1.0	100.0
NO/V4, W2	A1/V4	0.9	1.4
NO/W2	B2/W1, W2	0.9	3.1
F1/W1, W2	B2/W2	0.8	1.0
A1/V4	B1/W2	0.7	11.8
B2/W1, W2	NO/V4	0.7	0.7
NO/V4, W2	B2/W2, V4	0.7	1.0
B2/V4, W2	A1/V4	0.7	0.4
A2/V4, W1	A1/V2	0.6	48.2
NO/W2, V4	B2/W1, W2	0.6	4.8
B2/V4, W2	F1/V4	0.5	0.3
F1/W1, W2	B2/V4	0.5	0.6
NO/W1, W2	B2/W2, V4	0.5	18.2
NO/W2, W1	B2/W2	0.5	0.5
B2/W2, W1	A1/V2	0.5	-
B2/V4, W2	B2/V4	0.5	0.3
B2/V4	F1/W2, W1	0.5	0.9
A2/V4, W1	A1/V4	0.5	34.8
B2/W2, V4	M1/V4	0.4	0.2
NO/V4, W2	M1/ZO	0.4	0.6
B2/W2, V4	B2/V4	0.4	0.2
NO/W2, W1	NO/W1, W2	0.4	0.5
A1/V4	B1/W2, W1	0.4	5.8
F1/W1, W2	B2/V4, W2	0.3	0.4
A4/V4, YO	A1/V2	0.3	52.6
B2/XO, YO	B2/V4	0.3	100.0
B2/W2, W1	B1/W2, V4	0.3	-
B2/V4, W2	F1/W2, V4	0.3	0.2
NO/V4	A1/V3	0.2	1.5
B2/W2, W1	A1/V4	0.2	-
B2/W2, W1	B2/W2	0.2	-
B2/V4	B2/W2, V4	0.2	0.4
A4/V4, YO	A1/V3, YO	0.2	31.8
A2/V4, W1	A1, A2/V4, YO	0.2	12.3
F1/W1, V4	B2/V4	0.2	0.1
NO/W2	B2/V4	0.2	0.5
B2/V4	M1/V4	0.1	0.3
A1/V3	NO/W2, W1	0.1	0.6
NO/V4	B2/W2	0.1	0.7
F1/W1, W2	NO/V4	0.1	0.1
A4/V4, YO	A1/V4	0.1	15.6
B2/W2, V4	NO/W1, W2	0.1	-
A2/V4, W1	A1/V3	0.1	4.8
Total Area		1 430.2	50%

TABLE B14

CHANGES IN LAND USE, 1955-1972, MOOSE PIT BROOK, NOVA SCOTIA

From 1955	To 1972	Area (ha)	% Loss of 1955 Class
B2/W2, W1	NO/W2, W1	1 084.4	68.6
B2/W2, W1	B2/W2, V4	133.5	8.4
B2/W2, V4	NO/W2, W1	106.9	43.7
B2/W2	NO/W2	88.4	46.0
B2/W1, W2	NO/W2, W1	77.0	75.1
NO/W2	NO/W2, W1	73.7	59.0
B2/W2	NO/W2, W1	66.3	34.5
B2/V4, W2	NO/W2, W1	50.3	31.1
B2/W2, V4	NO/W2	41.4	16.9
B2/V4, W2	NO/W2	41.3	25.5
B2/W2, W1	NO/W2	41.1	2.6
B2/W2, V4	B2/W2, W1	25.3	10.3
B2/V4, W2	B2/W2, V4	24.5	15.2
NO/W2, W1	B2/V4, W2	18.8	16.0
NO/V4, W2	NO/ZO	18.2	35.8
F1/V4, W2	B2/W2, V4	17.3	84.1
B2/W2, W1	B2/V4, W2	17.3	1.1
B2/W1, W2	NO/W1, W2	16.4	16.0
F1/W2, W1	NO/W2, W1	15.2	62.6
F1/W2, V4	B2/W2, V4	15.0	63.7
A1/V3	A1/V4, W2	15.0	66.3
B2/W2	B2/W2, V4	13.3	6.9
B2/W2	B2/W2, W1	9.4	4.9
F1/W2, W1	B2/W2, V4	9.1	37.5
NO/W2	B2/W2, W1	7.0	5.6
F1/V4	B2/W2, V4	6.2	67.2
B2/V4	NO/W2, W1	5.5	34.8
B2/V4	NO/W2, V4	5.5	34.6
B2/W2	B2/V4, W2	5.5	2.8
B2/W1, W2	B2/V4, W2	5.3	5.2
B2/W2, W1	NO/W2, V4	4.8	0.3
B2/W2, V4	B2/V4, W2	4.3	1.7
B1/W2, V4	NO/W2, W1	4.2	100.0
M1/ZO	NO/ZO	3.6	100.0
F1/W2, V4	B2/V4, W2	3.4	14.4
B2/W2, W1	NO/V4, W2	3.2	0.2
F1/V4, W2	NO/W2, W1	3.1	15.1
B2/W2, W1	B2/XO	3.0	0.2
F1/W2, V4	NO/W2	2.8	11.8
F1/V4	NO/W2	2.7	28.7
A1/V3	NO/W2	2.5	11.0
NO/W2, W1	B2/W2, W1	2.3	2.0
B2/W1, W2	NO/W2	2.0	2.0
NO/W2	B2/V4, W2	1.9	1.6
NO/W2	B2/W2, V4	1.8	1.4
F1/W2, V4	NO/W2, W1	1.8	7.5
B2/W2, V4	NO/V4, W2	1.8	0.7
NO/V4	NO/W2	1.5	9.7
A1/V3	NO/W2, W1	1.5	6.7

TABLE B14 (cont'd)

From 1955	To 1972	Area (ha)	% Loss of 1955 Class
A1/V3	NO/W2, V4	1.4	6.3
NO/W1, W2	B2/W2, V4	1.3	5.6
A1, A2/V4, YO	NO/W2, V4	1.3	89.4
B2/W2, V4	NO/W2, V4	1.3	0.5
B1/V4	NO/W2, V4	1.2	100.0
NO/W1, W2	NO/W2	1.2	5.0
B2/V4	NO/V4	1.2	7.3
B1/W2	NO/W2	0.8	100.0
A1/V4	A1/V2	0.7	19.1
B2/V4, W2	B2/W2, W1	0.7	0.4
F1/W2, V4	B2/XO	0.6	2.5
A1/V2	NO/V4, W2	0.5	4.7
NO/V4, W2	NO/W2, W1	0.5	0.9
B2/V4	B2/W2, W1	0.5	2.9
M1/V4	B2/W2, V4	0.4	78.8
B1/W2, W1	NO/W2	0.4	100.0
F1/V4	NO/W2, W1	0.4	4.1
B2/V4	NO/W2	0.4	2.3
B2/W2, W1	NO/ZO	0.2	-
B2/V4	B2/V4, W2	0.2	1.4
B2/V4	B2/W2, V4	0.2	1.3
B2/W2, W1	NO/XO	0.1	-
B2/V4	NO/XO	0.1	0.8
M1/V4	NO/W2	0.1	21.2
B2/V4, XO	NO/W2	0.1	100.0
B1/V4, W2	NO/W2	0.1	100.0
A1/V3	A1/V2	0.1	0.3
B2/W2, W1	NO/XO	0.1	-
Total Change		2 122.4 ha	74%

TABLE B15

CHANGES IN LAND USE, 1928-1955, PEBBLELOGGITCH LAKE, NOVA SCOTIA

From 1928	To 1955	Area (ha)	% Loss of 1928 Class
NO/W2, W1	F1/V4, W2	326.1	27.1
NO/W1, W2	F1/W2, V4	160.6	37.0
NO/W2, W1	F1/V4	79.1	6.6
NO/W2, W1	F1/W2, V4	56.4	4.7
NO/W1, W2	F1/V4, W2	56.0	12.9
NO/W2, V4	F1/V4, W2	42.2	19.6
NO/W1, W2	F1/V4, W1	28.2	6.5
NO/W2	F1/V4, W2	18.5	37.3
NO/W2, W1	F1/W1, V4	15.6	1.3
NO/W2, W1	NO/W1, W2	11.6	1.0
NO/W2, W1	NO/V4, W2	10.5	0.9
NO/V4, W2	NO/W2, V4	10.3	24.1
NO/W2	F1/W2, V4	8.9	18.0
NO/W2, V4	F1/W2, V4	8.8	4.0
NO/W1, W2	F1/W1, V4	8.3	1.9
NO/W2	NO/W2, W1	8.2	16.6
NO/W1, W2	NO/V4, W2	6.3	1.4
NO/W2, W1	NO/W2, V4	5.6	0.5
ZO	M1/ZO	3.9	0.5
NO/W2, V4	NO/W2, W1	3.8	1.7
NO/W1, W2	NO/W2, V4	3.6	0.8
NO/W2, W1	F1/W2	2.6	0.2
NO/V4	NO/V4, W2	2.4	1.3
NO/W1, W2	F1/V4	1.7	0.4
NO/W1, W2	F2/XO, V4	1.4	0.3
NO/W2, W1	F2/XO, V4	1.4	0.1
NO/V4	NO/W1, W2	1.3	0.5
NO/V4, W2	F1/V4, W2	1.0	2.4
NO/W1, W2	NO/V4, W1	0.9	0.2
NO/W2, W1	F1/V4, W1	0.9	0.1
NO/W2, V4	NO/W2	0.8	0.3
NO/V4	NO/W2, V4	0.7	0.3
NO/W2, W1	NO/V4, W1	0.7	0.1
NO/W2, W1	F2/XO	0.5	-
NO/W1	F1/W2, V4	0.5	2.7
NO/W2, W1	F1/V4, XO	0.5	-
NO/W1, W2	MO/YO	0.2	-
NO/W2, V4	F2/XO, V4	0.2	-
NO/V4, W2	F1/V4, XO	0.1	0.1
NO/W1, W2	F2/XO	0.1	-
Total Change		890.4 ha	31%

TABLE B16

CHANGES IN LAND USE, 1955-1971, PEBBLELOGGITCH LAKE, NOVA SCOTIA

From 1955	To 1971	Area (ha)	% Loss of 1955 Class
F1/V4, W2	B2/W2, V4	302.2	68.1
F1/V4, W2	B2/W2, W1	137.1	30.9
F1/W2, V4	B2/W2, V4	132.6	56.4
NO/W1, W2	B2/W2, W1	131.3	73.2
NO/W2, W1	B2/W2, W1	109.1	15.5
F1/W2, V4	B2/W2, W1	101.6	43.2
F1/V4	B2/W2, V4	77.4	95.7
NO/W2, W1	B2/W2, V4	61.5	8.7
F1/W1, V4	B2/W2, W1	23.8	100.0
F1/V4, W1	B2/W2, V4	21.7	74.8
F1/V4, W1	B2/W2, W1	7.3	25.1
NO/W1, W2	B2/W2, V4	7.3	0.1
NO/W2, V4	B2/W2, W1	4.0	2.2
NO/W2, V4	NO/W2, W1	3.7	2.0
M1/ZO	NO/ZO	3.6	92.2
F1/V4, W2	B2/W1, W2	2.9	0.6
F1/W2	B2/W2, V4	2.6	100.0
NO/W2, V4	B2/W2, V4	1.9	1.0
F1/V4	B2/V4	1.7	2.1
F2/XO, V4	B2/V4, XO	1.5	51.8
F1/V4	B2/W2, W1	1.4	1.8
NO/V4, W2	B2/W2, W1	1.4	2.7
F2/XO, V4	B2/W2, V4	1.2	40.3
F1/V4, W2	B2/W1	0.9	0.2
NO/W2, W1	B2/W2	0.8	0.1
NO/V4	B2/W2, V4	0.7	0.3
NO/V4, W2	B2/W2, V4	0.5	1.0
NO/W2, V4	NO/W2	0.5	0.3
F1/V4, XO	B2/V4, W2	0.5	100.0
F1/V4, W2	B2/W2, W1	0.4	0.1
NO/W2	B2/W2, W1	0.4	3.0
F1/V4	B2/YO, V4	0.3	0.4
M1/ZO	B2/XO	0.3	7.8
F2/XO, V4	B2/XO	0.2	7.9
F1/V4, W2	B2/XO, V4	0.2	0.1
F2/XO	B2/V4	0.2	39.2
F2/XO	B2/V4, W2	0.2	30.6
NO/W2, W1	NO/V4	0.1	-
F2/XO	B2/XO	0.1	25.9
HO/YO	NO/XO, V4	0.1	66.1
F1/V4, W2	B2/YO, V4	0.1	-
HO/YO	NO/ZO	0.1	33.9
NO/V4	B2/W2	0.1	-
F2/XO	B2/W2, V4	0.1	4.3
Total Change		1 145.6 ha	38%

TABLE B17

CHANGES IN LAND USE, 1928-1955, WEST RIVER, NOVA SCOTIA

From 1928	To 1955	Area (ha)	% Loss of 1928 Class
NO/W2, V4	NO/W2, W1	367.2	21.7
NO/V4, W2	NO/W2, W1	348.2	40.8
NO/W2, W1	NO/W2, V4	157.8	2.5
NO/W2, W1	B2/W2, V4	82.6	1.3
NO/W2, V4	NO/W2	74.1	4.4
NO/W2, W1	NO/W1, W2	70.0	1.1
NO/W2, W1	NO/V4, W2	61.9	1.0
NO/V4, W2	NO/W2, V4	43.8	5.1
NO/W2, V4	NO/V4, W2	30.2	1.8
NO/W2, W1	B2/V4, W2	25.7	0.4
NO/W2, W1	F1/W2, V4	22.7	0.4
NO/W2, W1	NO/W2	20.8	0.3
NO/W2	NO/W2, W1	8.0	12.3
NO/V4	NO/W2, V4	7.5	2.3
NO/W2, W1	F1/V4, W2	4.6	0.1
NO/V4, W2	NO/W2	4.4	0.5
NO/W1, W2	NO/W2, V4	4.0	1.9
NO/V4, W2	NO/V4	2.5	0.3
NO/V4, W1	NO/W1	2.3	14.9
NO/W1, W2	NO/V4	2.3	1.1
NO/W1, W2	NO/W2, W1	0.5	0.2
NO/W2, V4	ZO	0.2	-
NO/W2, V4	NO/W1, W2	0.1	-
Total Change		1 341.4 ha	13%

TABLE B18

CHANGES IN LAND USE, 1955-1971, WEST RIVER, NOVA SCOTIA

From 1955	To 1971	Area (ha)	% Loss of 1955 Class
NO/W2, W1	NO/W1, W2	1 362.5	20.7
NO/W2, W1	B2/W2, W1	215.2	3.3
NO/W2, W1	B2/W2, V4	213.2	3.2
NO/V4, W2	NO/W2, W1	136.6	24.9
NO/V4, W2	NO/W2, V4	89.6	16.3
NO/W2, V4	NO/W2, W1	77.1	5.4
NO/W1, W2	B2/W2, W1	60.3	21.9
NO/W2	NO/W1, W2	26.2	16.8
NO/W2	NO/W2, W1	24.7	15.8
F1/W2, V4	B2/W2, W1	22.7	100.0
NO/W2, W1	NO/W2, V4	20.7	0.3
NO/W2, V4	B2/W2, W1	18.4	1.3
NO/W2, W1	B2/W2	16.3	0.2
B2/W2, V4	NO/W2, W1	15.2	18.4
B2/W2, V4	NO/W2, V4	10.7	12.9
NO/W1	B2/W2	8.7	16.1
B2/W2, V4	NO/W1, W2	6.0	7.2
F1/V4, W2	B2/W2, W1	4.6	100.0
NO/W2, V4	NO/W2	4.2	0.3
NO/W2, W1	NO/W1	3.1	-
NO/W1, V4	NO/W1, W2	2.7	9.6
NO/W1, W2	B2/W2, V4	1.7	0.6
NO/V4, W2	NO/ZO, V4	1.2	0.2
NO/V4	NO/W2, V4	0.8	0.2
NO/V4	NO/W1, W2	0.5	0.2
NO/W1	B2/YO, XO	0.4	0.8
NO/W2, V4	B2/W2, V4	0.4	-
NO/V4, W2	NO/W1, W2	0.2	-
Total Change		2 343.9 ha	22%